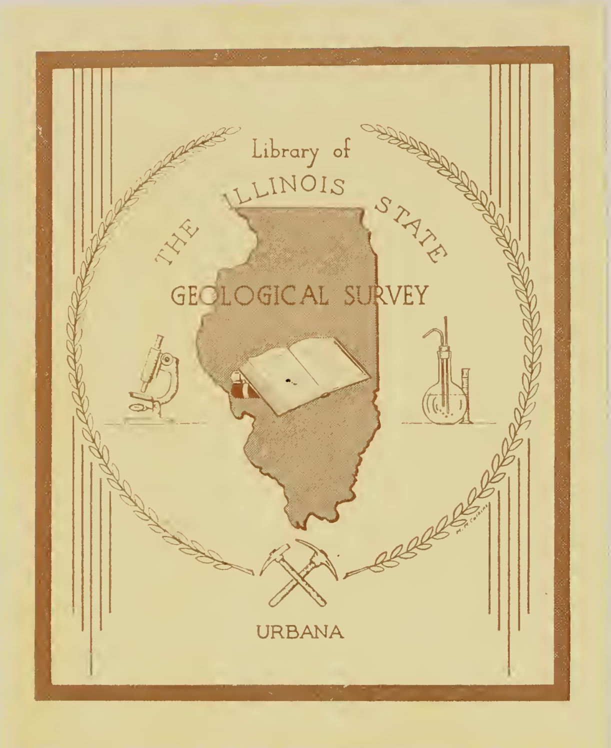
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FRANK W. DE WOLF, Chief

EXTRACT FROM BULLETIN No. 44

A RESTUDY OF THE STAUNTON GAS POOL

BY

L. A. MYLIUS

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DEPARTMENT OF REGISTRATION AND EDUCATION

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STATE GEOLOGICAL SURVEY
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OUTLINE

ILLUSTRATIONS

TABLES

INTRODUCTION

Acknowledgments

These reports are developed from two short visits to the pool in April and May 1919, from previous published reports, Oil and Gas in Bond, Macoupin and Montgomery counties[1], Oil and Gas in Gillespie and Mount Olive quadrangles[2], Petroleum in Illinois 1914 and 1915[3], and from information kindly given by Mr. L. H. Miller, Mr. Virgil Bachelor, Mr. T. A. Rinaker, the Cahokia Pipe Line Company, the Ohio Oil Company, and others. In interpreting data on the underlying strata the writer was guided chiefly by Dr. T. E. Savage.

The information on the whole was general and considerable difficulty was experienced in studying all conditions met with in the pool area.

The contour maps are developed from coal tests and skeleton logs which in most cases gave the position of No. 6 coal and the top of the sand.

[1]Blatchley, R. S., Oil and Gas in Bond, Macoupin, and Montgomery counties: Ill. State Geol. Survey Bull. 22, p. 41, 1913.
[2]Lee, Wallace, Oil and Gas in Gillespie and Mount Olive quadrangles: Ill. State Geol. Survey Bull. 31, p. 101, 1914.
[3]Kay, F. H., Petroleum in Illinois 1914 and 1915: Ill. State Geol. Survey Bull. 33, p. 80, 1916.

The graphs on pressure and flow were developed from two incomplete sets of figures. Although these figures cannot be guaranteed correct in any one detail, it is believed that they represent very well the general behavior of the pool.

Purpose

The object of these notes in the order in which they appear is:

1. To study the structure from well logs now available.
2. To study the decline in gas pressure and flow.
3. To study the sands.
4. To ascertain if possible the extent to which the field has been and is being handicapped by water trouble.
5. To present considerations for future drilling.

Location

The present gas pool covers parts of secs. 13, 14, 15, 22, 23, and 24, Dorchester Township, Macoupin County. The S½ of sec. 14, the center of the pool, is about three and one-half miles northwest of Staunton.

History

Illinois State Geological Survey Bulletin 33 covers the early history of this pool[1]. At that time seven wells had brought in gas. In August 1916 the Cahokia Pipe Line Company started to operate and began taking gas from the pool.

Most of the wells were drilled prior to 1917, but were turned into the pipe line at different times later on. The falling off of the gas late in 1918 stimulated the drilling of new wells mostly in the proven area. In all to date, May 1919, 26 wells gave gas in greater or less amounts, but only 19 have been turned into the pipe line.

L. H. Miller Oil and Gas Company, Miller Brothers Oil and Gas Company, Superior Oil and Gas Company, Miller Estate Oil and Gas Company, Lambert and Fleeger, and Bachelor Brothers, all of Staunton; Ibbotson and Rinaker, Carlinville; Monks Mound Oil and Gas Company, St. Louis; C. H. Turner, Casey, Illinois, are parties interested.

The Cahokia Pipe Line Company of East St. Louis, has lines to Staunton, Edwardsville, Collinsville, East St. Louis, and Belleville. About December, 1918, compressors were installed at Edwardsville to overcome the disadvantage of low pressure in the pipe line. On April 23, 1919, permission was obtained by the above company to restore artificial gas service in Edwardsville.

[1] Kay, F. H., Petroleum in Illinois 1914 and 1915: Ill. State Geol. Survey Bull. 33, p. 80, 1916.

GEOLOGY

General Section

The accompanying section is compiled from a study of the underlying strata from well logs, samples of drillings, and publications on the adjoining counties and the general vicinity of Staunton.

Log of Well No. 8

The accompanying log of well No. 8 shows to a depth of about 1500 feet, the character of the strata in the immediate vicinity of the Staunton dome.

Log of Well No. 8[1]*, Ohio Oil Company, on the George Groves farm in sec. 15, Dorchester Township*

NE SE N

Elv. 574

	Thickness *Feet*	Depth *Feet*
Water		at 15
Shale, blue	50	126
Lime	2	128
Shales, dark muddy	21	149
Lime	1	150
Slate, blue	20	170
Slate, sandy	25	195
Lime	4	199
Shale, blue	16	215
Lime	15	230
Shale	7	237
Lime	5	242
Coal, *No. 6*	6	248
Lime	8	256
Shale, blue	10	266
Lime	20	286
Shale, hard black	44	330
Shale, blue	6	336
Shale, white	84	420
Shale, blue	43	463
Sand (gas)		at 463
Gas	12	475
Showing of oil	7	482
Water, salt	28	510
Shale, brown	20	530
Sand, salt	70	600
Showing of green oil		at 565
Sand, water	35	600
Lime, "*Big Lime*"	300	900
Sand, black, and shale	45	945
Slate and sand	70	1015
Lime, white	205	1220
Lime, black	50	1270
Red rock	5	1275
Lime, blue	10	1285
Lime, red	15	1300
Shale, red	8	1308
Lime, of various colors	27	1335
Slate, black	25	1360
Slate, sandy	40	1400
Shale, black	10	1410
Shale, brown	15	1425
Sand	25	1450
Lime, *Niagaran*	50	1500

[1]Well numbers here and throughout the report have reference to those used on the map, Plate I, and in the Table of Well Data.

STRUCTURE OF THE STAUNTON DOME

The records of most of the wells drilled since 1915 give the depth to No. 6 coal. This enables the structure of the coal to be shown in more detail on the accompanying map, Plate I, than was possible at the time Plate IX of Bulletin 31[1] was published.

The long axis of the dome runs about 40 degrees west of north from the center of sec. 24 to the center of sec. 10, T. 7 N., R. 7 W. The beds dip at a higher angle on the northeast side of the dome than on the southwest side. The highest and widest part of the dome is mainly in sec. 14. The beds continue high toward the northwest from sec. 14, but drop considerably toward the southeast.

No contours are drawn in the outlying sections as the data now available do not show any decided signs of new anticlinal structure. The actual structure in sec. 24 is not very clear as yet.

TABLE OF WELL DATA

Table I contains most of the well detail in a form that is hoped will allow comparisons between the different wells. The wells are numbered to simplify reference. All figures used, pertaining to wells, in the body of this paper are taken from the accompanying table.

GAS PRESSURE AND FLOW

The flow and pressure curves (Plate III) are developed from two sets of figures for the same wells which when compared do not always check. The pressure readings after the pressure became as low as 15 pounds are not accurate, as the meter installations were for considerably higher pressures.

The lowest group of curves on Plate III was made up by taking an approximate day's flow from each well or set of wells on the same meter, each month. The total daily flow immediately above was drawn using the totals of the individual curves. The load curve does not represent the total output per month, but is introduced to show the sensitiveness of the well behavior to the load. The curves showing pressure, gaged in pounds per square inch, agree closely and are *all* plotted to bring out that point. The graph for the number of wells represents the number turned into the pipe line.

The initial gage pressure of the early wells was from 155 to 160 pounds per square inch. Up until January, 1917, only about 16,000,000 cubic feet of gas was drawn from the pool and the drop in pressure to 135 pounds would indicate considerable waste. From January, 1917, to July, 1917, five wells (3 graphs) were supplying gas. A rather gradual drop in pressure resulted from 135 to 120 pounds. In August the introduction of Nos. 5 and 6 seems to have taken a big part of the load from Nos. 1, 2, and 3, due probably to temporary slightly higher pressure, but from October the flow of all the wells with the exception of No. 9 rose to meet the increasing load which had its peak in January, 1918, when nine wells were producing and the pressure had dropped to about 60 pounds. The steepening of the pressure decline

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[1] Lee, Wallace, Oil and Gas in Gillespie and Mt. Olive quadrangles: Ill. State Geol. Survey Bull. 31, p. 101, 1915.

TABLE I.—*Table of well data*

Well Number[a]	LOCATION ¼	Sec.	PROPERTY	Surface elevation	No. 6 coal: Depth to top	No. 6 coal: Elevation of top	SANDS: Depth to top	SANDS: Elevation of top	SANDS: Elevation of best pay
	Dorchester Twp.								
46	9	NW	F. Stamme	646	......	......	......	......	......
[b]15	9	NE	Superior Coal Co.	645	309	336	......	......	......
[b]17	10	NE	do	645	297	348	......	......	......
[b] 7	10	NE	do	639	310	329	......	......	......
[b]22	10	SE	do	644	306	338	......	......	......
36	12	NW	C. C. Isaacs	634	289	345	502	132	......
34	13	SE	C. Schmutzler	551	230	321	......	......	......
18	14	NW	Miller Estate	580	222	358	416	164	148
47	14	NE	Wall	621	......	......	......	......	......
33	14	NE	J. Coatney	613	296	317	......	......	......
19	14	SW	Harrison Woolridge	611	247 ?	364	467	144	109
10	14	SW	do	613	......	......	......	......	......
1	14	SW	Dan Groves	612	245	367	441	171	......
3	14	SW	do	611	248	363	464	147	......
4	14	SE	Schoolhouse	612	252	360	480	132	122
16	14	SE	Godfrey	609	257	352	482	127	......
7	14	SE	do	610	......	......	......	......	120 ?
12	14	SE	Alonzo Woolridge	612	257 ?	355 ?	512 ?	101 ?	......
44	15	NW	C. Schweitzer	621	285 ?	336 ?	......	......	......
8	15	NW	George Groves	574	242	332	461	113	111
20	15	NE	Lancaster	612	268	344	476	136	121
17	15	NE	Rice	613	260	353	476	137	124
21	15	NE	Brockman	596	240	356	441	155	118
32	21	NE	A. Bauer	588	248	340	496	92	......
[b] 8	22	NW	Superior Coal Co.	609	276	333	......	......	......
30	22	NE	Shrier	595	243	352	......	......	......
9	22	NE	A. Fletcher	608	260	348	470	138	......
2	23	NW	D. Groves	612	247	365	442	170	152
13	23	NE	Superior Coal Co.	610	247	363	464	146	......
14	23	NE	do	609	249	360	462	147	......
[b]11	23	NE	do	609	249	360	......	......	......
5	23	NE	Hamp Woolridge	585	224	361	430	155	......
6	23	NE	do	608	246	362	485	123	......
15	23	NE	Harrison Woolridge	609	256	353	489	120	......
22	23	NE	V. Schweitzer	605	260	345	462	143	116
42	23	SW	E. G. Wilder	601	273	328	......	......	......
43	23	SW	Sawyer	......	......	......	......	......	......
29	23	SE	A. G. Schnaare	600	270	330	465	135	......
27	24	NW	H. Adler	571	240	331	453	116	......
28	24	NW	do	581	251	331	487	94	......
23	24	NW	do	534	205	329	429	105	......
45	24	SW	Blank	......	......	......	......	......	......
26	24	NE	L. Schnaare	531	......	......	......	......	......
25	24	SW	do	532	200	332	440	92	......
24	24	SE	do	529	185	344	417	112	......
[b]	24	center	Superior Coal Co.	531	......	331	......	......	......
11	24	SW	E. D. Wilder	530	202	328	424	106	......
40	25	SW	N Smith	532	195	337	426	106	......
39	25	SE	D. Funderburk	599	260	339	510	89	......
38	25	SE	do	533	195	338	445	88	......
[c]	25	SE	....	552	202	340	......	......	......
[b]10	26	SW	Superior Coal Co.	589	242	347	......	......	......
31	27	NE	C. Bruhn	600	265	335	520	80	......
[b] 9	28	SE	Superior Coal Co.	590	242	348	......	......	......
				......	......	......	......	......	......
	Staunton Twp.			......	......	......	......	......	......
				......	......	......	......	......	......
35	19	NW	....	553	......	353	......	......	......
37	19	NW	Dingerson	......	......	......	......	......	......
[c]	30	NW	....	616	275	341	......	......	......
41	30	SW	Miller	604	......	......	517	87	......

[a] Well numbers refer to those used on the map, Plate I, and throughout the report
[b] Coal bore
[c] Mine shaft

for the Staunton gas pool.

SANDS			Interval between top of No. 6 coal and:					
Elevation of oil show	Thickness	Depth of hole	Top of sand	Best pay	Oil show	Bottom of hole	Original rating in 100 M cu. ft. of gas per 24 hours	REMARKS
......	......	592	......	......	......	......	....	Dry
......	......	317	......	......	......	......		
......	......	305	......	......	......	......		
......	......	319	......	......	......	......		
......	......	405	......	......	......	......		
......	......	511	213	......	......	222	....	Into salt water; dry hole
......	......	660	......	......	......	330	....	Dry
......	44+	460	194	210	......	238	....	Producer; sand broken
......	......	......	......	......	......	......	....	Dry
......	......	545	......	......	......	249	....	Dry
......	......	515	220	255	......	268	....	Part time producer; water
......	......	......	......	......	......	......	4500	Producer
......	24+	465	196	......	......	220	4327	Producer
......	36+	500	201	......	......	252	25061	Producer
......	24+	504	228	243	......	252	5200	Producer
......	18+	500	225	......	......	243	3500	Producer
......	......	515	......	......	......	......	7670	Producer
......	......	525	244	......	......	268	6240	Producer
......	......	615	......	......	......	330	....	Dry
96 9	19	1500	219	221	236 323	......	2200	Producer; salt water
93	24	521	208	223	251	253	....	Gas; into water
......	......	516	216	229	......	256	3500	Producer
101	31	497	201	238	255	257	2700	Gas; had "fire clay," 472-78
......	......	571	248	......	......	323	....	Dry
......	......	283	......	......	......	......		
111 67	......	528	......	......	241 195	285	....	Dry; into a little water
......	251	495	210	......	......	235	5460	Producer
......	......	490	195	213	......	243	9528	Producer
......	36+	500	217	......	......	253	....	Producer
......	38+	500	213	......	......	251	....	Producer
......	......	258	......	......	......	......		
......	40+	470	206	......	......	246	10000	Producer
......	12 ?	507	239	......	......	261	....	Producer
......	16+	506	233	......	......	250	10630	Producer
......	......	520	202	......	......	260	235	Show of gas
......	......	510	......	......	......	237	....	Dry
......	......	......	......	......	......	......	....	Dry
......	20	610	195	......	......	340	....	Show of gas
96	20	480	215	......	235	240	....	Show of gas
91	13	506	237	......	240	255	....	Show of gas; into water
......	18	447	224	......	......	242	1500	Gas
......	......	......	......	......	......	......	....	Dry
......	......	......	......	......	......	......	....	Show of oil
......	......	466	240	......	......	266	....	Show of oil
85	6 ?	450	282	......	259	265	....	Show of oil
......	......	......	......	......	......	......		
......	......	444	222	......	......	242	786	Producer; good oil show
......	......	474	231	......	......	279	....	Dry
......	......	671	250	......	......	411	....	Dry; into salt water
88	8	474	250	......	250	279	....	Dry
......	......	......	......	......	......	......		
......	......	249	......	......	......	......		
......	......	525	255	......	......	260	....	Dry; into salt water
......	......	......	......	......	......	......	....	
......	......	......	......	......	......	......	....	
......	......	......	......	......	......	......	....	
......	......	......	......	......	......	......	....	
......	......	......	......	......	......	......		Dry
......	......	601	......	......	......	......		Show of gas; into salt water
......	......	......	......	......	......	......	....	
......	......	......	......	......	......	......		Dry

started about September when the load commenced to increase. The pressure curve of well No. 4 shows evidence of water trouble. In May 1918, with 12 wells producing and with the lighter summer load the pressure had dropped to about 40 pounds. All wells except No. 11 showed a considerable reduction in flow on the turning in of well No. 17 in September. In November, 1918, when the winter load began to be felt, there were 15 wells and in December, 17 wells producing, and the pressure had dropped to about 20 pounds. With 17 wells during the rest of the season the flow fell considerably below the winter of 1917-18 when 9 to 11 wells were producing. The temporary recovery of pressure from August, 1918, to December was probably due to new wells, notably Nos. 17, 8, 13, and 14, taking the load and giving the other wells a chance to "come back" while they expended their slight advantage of pressure. In April, 1919, the pressure was down to 4 to 5 pounds when with 18 wells the flow was lower than at any time since August, 1917.

An approximate figure for the production of gas to May, 1919 would be 1, 050,000,000 cubic feet. Of this amount the central group of wells (S½ sec. 14 and N½ sec. 23) supplied about 87 per cent, the northwest group (NE¼ sec. 15) supplied about 10½ per cent, and the southeast group (sec. 24) supplied about 2½ per cent.

SANDS

Contours

The contours on the top of the sand (Plate II in pocket) agree closely with those of No. 6 coal (Plate I) and show that the coal contours defined the productive gas sand area.

Thickness

The sands appear to vary considerably in thickness being best developed at the top of the dome. This has caused the sand contours to be more accentuated than the coal, notably at Nos. 1, 2, 5, and 18. On the highest contours No. 2 seems to be the only well that has gone through the sand; it showed 48 feet. Nos. 3 and 13 were still in sand after penetrating 36 feet, No. 14 after 38 feet, and No. 5 after 40 feet. As regards the probability of a second sand the only definite break recorded is in well No. 21 where 6 feet of "fire clay", following 31 feet of sand, came before a second sand which showed oil. Well No. 20 also seems to show a break below 24 feet of upper sand. The sands thin somewhat on the edges of the dome. Nos. 8 and 27 show 19 and 20 feet of sand respectively with oil shows near the bottom and well No. 29 shows 20 feet of sand. Either the two sands have run together or the break was missed. Well No. 24 shows gas in 6 feet of sand and oil in a sand 25 feet deeper. The average interval between the top of the gas sand and the top of No. 6 coal is 218 feet while the average interval for eight "oil shows" is 246 feet. In places at least two distinct sands appear, and it is possible they run together in other

places. The depths of the gas sand and the "oil shows" below No. 6 coal seem to indicate that each constitutes a separate horizon. That shale or other rock replaces the sand in places is perhaps shown by Nos. 18 and 30 where the sands were broken and by well No. 24 which has about 6 feet of gas sand and an oil show in a sand 25 feet lower but at the horizon of the other oil shows.

Distribution

In the central group of producing wells, secs. 14 and 23, the sands seem to be thickest. This group produced about 87 per cent of the gas up to May, 1919. In consulting the curves it is very evident that the pressure and flow of all of these wells were in very close sympathy. Going toward the northwest group which produced 10½ per cent of the gas, the sands appear fairly thick, but in places broken and tighter. Gas connection undoubtedly exists between the northwest group and the central group but it is restricted to a certain extent. Going southeast toward the group in sec. 24 the contour drops about 30 feet and the sands become somewhat thinner. Only one well has produced from this southeast group and its behavior shows that the sand is more isolated than is the sand of the northwest group. However, all new wells over the whole pool, in most cases having a few pounds more pressure than the operating wells when turned in, dropped very quickly to general pool conditions of pressure and flow.

The dry holes in and around the dome show the presence of the sand, and some farther away, namely Nos. 38, 39, and 40, also show sand at approximately the same distance below the coal as the sand in the producing wells.

Porosity

As would be expected, the structure has had very marked effect on the gas production. The producing wells with two exceptions are all on the high contour. The physical condition, chiefly the porosity, of the sand also affects gas accumulation as shown by some dry holes on relatively high structure. Some wells that encountered the top of the gas sand at higher elevations than neighboring wells were not so good producers. This porosity may account for the two gassers on the lower contour but both these wells, Nos. 8 and 11, are also more isolated and have not had to "share their gas" to the same extent as other wells. It would seem that the sands in places have one or more highly porous layers. This fact caused a considerable lowering of pressure and exhaustion of the gas by the first wells in the central group; later, new wells brought increased flow for very short periods only, and some wells have proved quite insignificant that would have given a good flow had they been among the first drilled in the group.

Considerations on the Extent of Exhaustion

Before considering the extent of exhaustion of the gas in the present gas sand at Staunton, the following notes on the closed-pressure method of estimating exhaustion which cover many con-

ditions are reprinted from the Manual for the Oil and Gas Industry published by the U. S. Treasury Department, 1919:[1]

CLOSED-PRESSURE METHOD

"Because of its general applicability, the closed-pressure method is by far the best method of estimating the depletion of gas properties.

"Unfortunately, accurate closed-pressure data have not been kept for all properties or perhaps even for the majority of properties, but the rock pressure in most pools is known or is ascertainable with a fair degree of accuracy, and the information drawn from the pressure decline is, with the exception of a few fields, not subject to profound modification, because of factors whose value can not be appraised. The basis of this method is Boyle's law. According to this law of physics, if gas is pumped into a vessel until the pressure is 200 pounds and then is drawn off until the pressure is 100 pounds, the size of the vessel remaining fixed, and ignoring for the moment atmospheric pressure, it may be concluded that one-half of the gas has been drawn out of the vessel. If an underground gas reservoir of fixed dimensions is tapped by wells and the pressure is found to be a thousand pounds, and then if the gas is drawn off through the wells until the gas pressure in the pool is lowered to 100 pounds, we may infer that about nine-tenths of the supply of gas has been exhausted."

CORRECTIONS AND REFINEMENTS OF CLOSED-PRESSURE METHOD

"Several corrections and more or less important refinements are made in applying this method to the computation of depletion, and it should be borne in mind that it does not afford data on the *amount* of gas originally in the pool or at any later specified time, but only the *fraction* of the gas that has been removed from its natural reservoir and the fraction remaining in that reservoir. Perhaps the most important of these corrections arises out of the fact that the size of the reservoir does not remain fixed but becomes smaller as the gas is drawn and water or oil advances into a part of the space formerly occupied by the gas. The pressure is thus prevented from declining at a rate proportionate to the amount of gas drawn from the pool. The correction on account of water or oil encroachment is difficult to make, because of the lack of data to determine the extent of the encroachment. However, in a good many pools, after a study of the distribution of wells that have been "drowned out" and the history of water troubles in similar near-by pools, it is possible to make allowance for water or oil encroachment which will more or less closely approximate the facts.

"Another refinement applicable to the computation of depletion of natural gas by the closed-pressure method is based upon the fact

[1]Manual for the oil and gas industry, Revenue Act of 1918: Treasury Dept., U. S. Internal Revenue, pp. 31-33, 1919.

that even where there is not encroachment of water or oil the depletion is not precisely represented by the gage readings, though the errors are generally so small that they may be ignored. For example, where the pressure declines from 1,000 to 500 pounds, the gas is not exactly half gone, for the reason the pressures referred to are gage readings and to each should be added the pressure of the atmosphere —for most fields about 14.4 pounds to the square inch. The fraction remaining in the ground then becomes 514.4/1014.4.

"Account should also be taken of the pressure at which wells are abandoned in the field or district.

"If wells can not be operated with profit after the pressure has declined to 25 pounds gage reading (39.4 pounds absolute), then the percentage of recoverable gas remaining when the pressure has declined from 1,000 to 500 pounds gage reading is not one-half or even the fraction 514.4/1014.4 but 475/975. The difference in the fraction where pressures of several hundred pounds are involved is not great and scarcely worth considering in view of the other errors which are certain to affect the result. However, after the pressure has declined to a low figure, the matter of correcting the fraction becomes of considerable importance. Thus, if the pressure of abandonment is 4 pounds gage reading, and during the year the average closed pressure of a pool has declined from 10 pounds to 5 pounds gage reading, five-sixths instead of one-half of the recoverable gas has been withdrawn.

"Still another refinement that has, as a rule, more theoretical than practical value may be worthy of consideration in certain instances. This arises out of the fact that gases do not expand precisely as the pressure decreases, and that even if the size of the natural reservoir remains fixed the pressure does not decline in exact proportion to the amount of gas removed. The difference amounts to only a few per cent and is greatest for high pressures. In the decline from 1,000 to 500 pounds per square inch the gas expands several per cent more than would be calculated by a strict application of Boyle's law, and in a decline from 1,500 to 1,000 pounds the departure is still greater. The correction varies from field to field because of the different constitution of the gases, though since most natural gases consist largely of methane the variations on account of differences in gases are not great.

"A fourth detail of refinement arises out of the fact that on the average more gas is marketed for 50 pounds of decline in pressure after the pressure has reached 100 pounds or less than an equal decline while the pressure is high, as, for example, 1,000 pounds per square inch. Also the expense of marketing gas after the pressure has become low is greater than when it was high, largely because of the necessity of installing compressors to push the gas through the pipe lines to the consumers. These two considerations have a tendency to balance each other and, with certain exceptions, will not be of sufficient importance to warrant an attempt to apply the corrections.

METHOD OF GAGING

"In using the closed-pressure method of estimating depletion, the method of gaging is of vital importance and in many fields is not carried out with sufficient care. Care should be taken to make sure that the gage is accurate, testing it before and after attaching it to the well. If it must be transported far or is subject to much jolting in transportation, a gage tester should be taken along and used at the well.

"Care should also be taken to empty the well of oil and water by pumping, blowing, or siphoning before attaching the gage, for any liquid in the hole will lower the closed pressure reading.

"The well should be closed long enough to allow the pressure to build up to its maximum. The length of time necessary for this purpose varies a great deal from field to field and well to well. The well should remain closed until the pressure will not build up more than 1 per cent in 10 minutes. Ordinarily, 24 hours will be sufficient for this purpose, but for some wells several days or even a longer period will be required, owing to the slowness of equalization of pressure in the sand."

APPLICATION AT STAUNTON

As application of the closed-pressure method to any one well at Staunton might not give the desired result, most of the wells should perhaps be tested at the same time. What the closed-gage pressure at Staunton was in May, 1919, is not known. It might be higher than the pressure curves would lead one to suppose. It is evident, however, that starting at a rock pressure of 160 pounds the present pressures indicate that by far the greater part of the gas to be expected from the producing gas sands has been withdrawn.

It is worthy of note that the original ratings of producers (see Table I) were greatly in excess of their actual productions. To illustrate: wells No. 1, 2, and 3 had a combined rating of 38,900,000 cubic feet per 24 hours. These wells produced, at their highest, approximately 38,000,000 cubic feet during the whole month and they averaged per month in 1917 about 20,000,000 cubic feet or 1/58th of the original rating. The other figures show similar results to a greater or less extent, a notable exception being well No. 11.

WATER ENCOUNTERED AND ITS EFFECTS

The log of well No. 8 above shows a water sand at an elevation of 92 feet above sea level, another at an elevation of 44 feet, and a heavy water at an elevation of 9 feet. The water in this hole was plugged off and a good flow of gas obtained.

Other wells that struck water in or near the productive area are: No. 21, elevation 99 feet; No. 20, elevation 91 feet; No. 19, elevation 96 feet; No. 30, elevation 67 feet; No. 11, elevation 86 feet; No. 24, elevation 85 feet; No. 27, elevation 75 feet; No. 23, elevation 86 feet. It is doubtful if any of these wells reached the lower waters, encountered at elevations of 44 feet and 9 feet in well No. 8.

In well No. 21 the water was sufficient to drown off the gas after being allowed to stand and is no doubt flooding the sands locally. Well No. 20 after standing for months, had about 200 feet of water in the hole when cleaned out in May, 1919. The sands here were evidently subjected to water under a high head. Well No. 19 was still standing with a large head of water, not having produced for months, and the sands were unprotected. Well No. 30 was a dry hole. Well No. 11 blows off the small amount of water it makes through a one-inch perforated pipe. Well No. 24 was shot for oil and did not prove to be a producer of either oil or gas. No. 23 had a 3-foot plug of cement put in the bottom of the hole and arrangements were being made to put this well on pumping. Well No. 27 is plugged. No doubt the amount of water made by these wells is relatively small and shows up on accumulation. However, where allowed to accumulate, it locally must be flooding the sands, especially with the gas pressure decreased. It is understood to be sweet water.

Farther away from the producing area wells No. 39, 37, 36, and other dry holes struck water, most of them going into the heavy salt water above the "Big Lime." It is doubtful if these wells caused any flooding of the sands that would affect the producing area.

Until late in 1918 only two wells not mentioned above were affected by water trouble. Well No. 9, after having one inch perforated tubing installed, gave little trouble until the above time. Well No. 4 had a leaky casing and this was remedied by putting in a 4-inch string.

The usual procedure is to land the casing (6½ inch) on top of the gas sand; a few wells have wall packers. No doubt in most wells the nature of the casing seat lets some water into the hole. The producing wells at first easily blew off the small amount of water made, but when the pressure dropped below 20 pounds, the water became more evident. Late in 1918 this stimulated considerable installation of two-inch tubing with packer and anchor, and a "T" placed at the top of the sand for an opening. Wells No. 3, 15, 16, 7, 6, 13, and 18, all producers, had been tubed in the spring of 1919, as had also wells No. 20, 23, and 19, not then turned into the pipe line. The other producers continued to give gas from the casing head, some being hampered as the pressure decreased. With low pressure, a relatively small quantity of water soon heads off and traps the gas. Those wells that had not been drilled into water, when cleaned out after standing some time, showed only 20 to 40 feet of water in the hole. It seems that the water which began to make trouble late in 1918 was relatively small in amount.

There is no evidence to show that water came up the dip of the sand from the edges of the dome. It would appear that the water has not as yet encroached on the gas sand or to any considerable extent been a factor in the falling off of the gas production; rather, it came into prominence at the falling off of the gas pressure. It is now a source of trouble to the well owners, and those cases of indifference in well procedure that exposed the sands to water are now more likely

to bring about a condition that will make the recovery of the gas still remaining in the sands impracticable or very difficult.

If the load on the pool is lessened the gas pressure may build up somewhat and the installation of bleeders on the tubing might handle the water. If it should not, it would be necessary to employ some system of pumping off the water before it gains much head.

FUTURE DRILLING CONSIDERATIONS

Present Gas Sand

It is evident that the bulk of the gas has already been drawn from the present gas sand. The excessive number of wells has no doubt increased the waste. The pool has taken too big a load, and the very short stimulation brought by new wells only hastens exhaustion. In view of the nature of the structural uncertainty in the SE. ¼ sec. 24, the reappearance of good oil and gas shows in wells Nos. 11, 24, and others after the dry holes between there and the central group, and the behavior of the gas in well No. 11, suggesting that it may be more isolated from the central group than has been assumed, would indicate that a doming may occur along the continuation of the anticlinal axis toward the southeast. A well in or near the SE. ¼ SE. ¼ sec. 24 or close in to the common corner in sec. 25, Dorchester Township, and secs. 19 and 30, Staunton Township, would test the possibility for shallow oil or gas. If the doming occurs here, most of the discussion to follow on oil possibilities for the known dome would be applicable. Northwestward near the SE. ¼ sec. 10, a well might be expected to strike gas, but it would doubtless share in the flow from the northwest group. With the above exception in and near the SE. ¼ SE. ¼ sec. 24, it would not seem advisable to drill any more for this shallow gas in secs. 10, 11, 12, 13, 14, 15, 22, 23, and 24.

What is wanted is an isolated dome similar to the one now known. With the possible exception noted above, nothing in the area covered by this map (Plate I) indicates favorable structure. The possibility of similar domes outside the area covered by this map can not be discussed, as the working up of these notes gave no new information.

Known Horizon of Oil Shows

On the top of the dome oil may occur in commercial quantities closely underlying the productive gas sand. At Carlinville, oil was found in a sand which in places seemed to be a continuation of the gas sand, and in other places was found as much as 40 feet below the gas sand.[1] At Staunton due to the lack of detailed logs and also to somewhat different conditions, a study of this point is not decisive, but a similar underlying sand seems to exist here. Wells No. 23, 27, 28, 20, 21, 11, 24, 30, and 8 showed oil at an average depth of 246 feet below the top of No. 6 Coal, while the average depth of the gas sand is 218 feet below. Of these wells, the No. 6 coal in well No. 30

[1] Lee, Wallace, Oil and Gas in Gillespie and Mount Olive quadrangles: Ill. State Geol. Survey Bull. 31, p. 71, 1915.

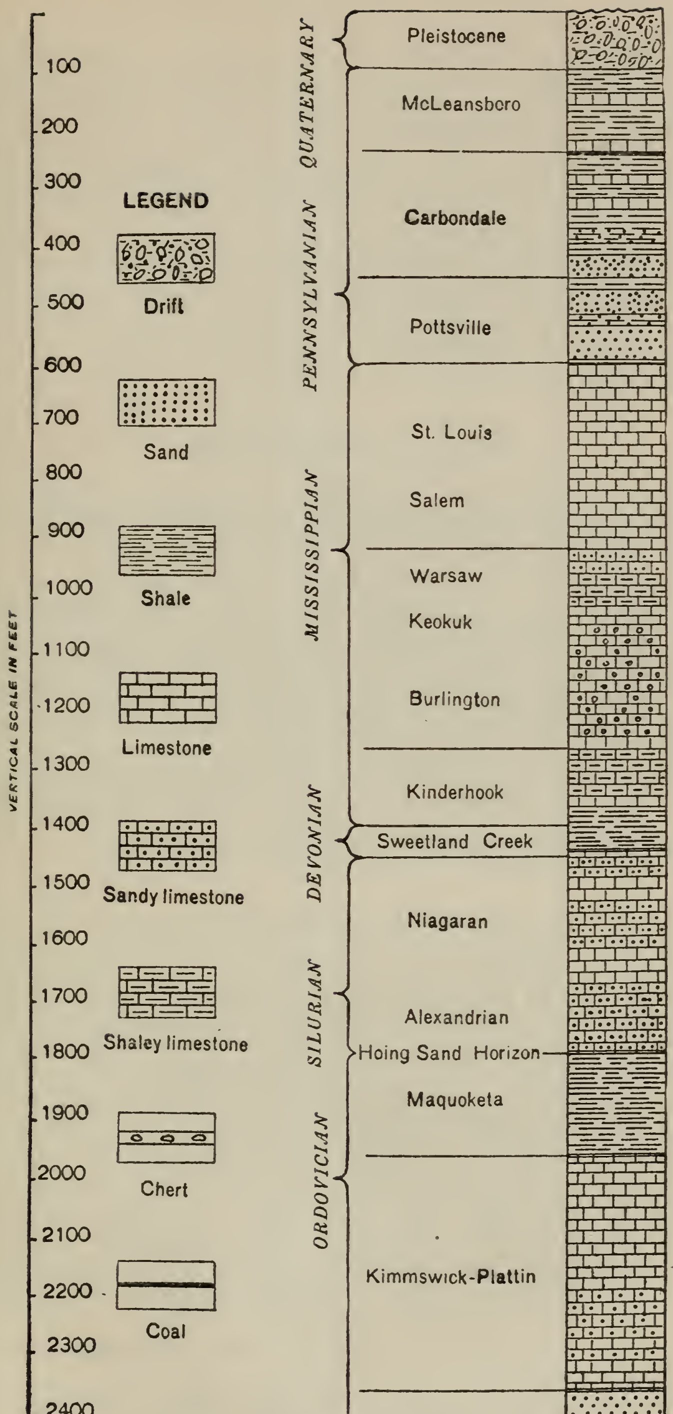

FIG. 1—Graphic section showing beds to be penetrated in deep drilling for oil in the vicinity of Staunton.

is at an elevation of 352 feet and the hole was dry, the sand being very broken. In well No. 21 the coal has an elevation of 356 feet and the lower sand has not been tested properly for oil. Nos. 11 and 24 had good oil showings, No. 24 having been reported as making 4 barrels on the beam after being shot. With the exception of perhaps Nos. 24, 25, and 26, which proved unproductive, no wells having been shot.

A flow of gas was found in well No. 19 at 255 feet below No. 6 coal which is the horizon of the oil shows. Several other wells, Nos. 12, 7, 6, and 22, went approximately deep enough to test this horizon without recording oil. But on the whole it would seem that this oil possibility deserves a proper test. A well within and near the 360-foot coal contour could perhaps mud or case off the gas sand and give this horizon a good test.

Deeper Possible Horizons

It should be noted that in drilling through the present gas sand to deeper horizons, precautions should be taken to protect the producing gas sand and horizons to be tested, from water.

The question of oil possibilities at deeper horizons is pertinent. The Staunton dome being the only known favorable structure in this immediate area presents the logical location for any deeper wells to test lower horizons. Although unconformities may exist, it has been found in many cases in this State that structure indicated by the "Coal Measures" is found in the underlying strata to exist in sufficient degree to have caused the accumulation of oil. This is exemplified on the western side of Illinois in the Plymouth pool in McDonough County,[1] where the mapping and description of a dome on No. 2 coal led to the development of an oil pool in the "Hoing" sand occurring there at the base of the Niagaran (Silurian) limestone.

STE. GENEVIEVE LIMESTONE

As shown in other parts of the State, the next likely horizon for oil to be expected at Staunton below the known oil shows is that of the Ste. Genevieve limestone ("green oil" horizon) which is the uppermost formation of the "Big Lime." It is not known whether the Ste. Genevieve occurs under the Staunton dome. Weller[2] shows 48 feet of Ste. Genevieve in the cliffs at Alton, about 20 miles southwest of Staunton, but according to Worthen[3] the beds thin out to the north. Well No. 8 in sec. 15 of Dorchester Township, wells in Bond County to the southeast, wells in Madison County to the south, wells in Montgomery county to the east, and wells near Carlinville to the north do not show whether the Ste. Genevieve is represented. The productive beds in this formation are sometimes as thin as 2 or 3 feet and might easily be overlooked where they are not productive. The log of well

[1]Hinds, Henry, Oil and Gas in the Colchester and Macomb quadrangles: Ill. State Geol. Survey Bull. 23, pp. 11-13, 1914.

[2]Weller, Stuart, Mississippian Brachiopian: Ill. State Geol. Survey Monograph I, p. 22, 1913.

[3]Worthen, A. H. Geology of Jersey County: Geol. Survey of Ill., Vol. III, Chap. VI, p. 111, 1868.

No. 8 given on a previous page showed green oil at 565 feet. Only two wells, Nos. 8 and 29, close in on the dome reached the "Big Lime." Others, Nos. 34, 39, and 37, some distance away, also reached the "Big Lime."

The following table illustrates the irregularity in the interval between the eroded surface of the "Big Lime" and the top of No. 6 coal.

Well number	Section	Township	Elevation top No. 6 coal *Feet*	Elevation top "Big Lime" *Feet*	Interval *Feet*
8	15	Dorchester	332	—25	357
29	24	Dorchester	330	—10	340
39	25	Dorchester	339	—77	416
34	23	Dorchester	321	—104	425
37	19	Staunton	.....	....	386

It is not known whether the interval is less under the dome than elsewhere and these few figures are not sufficient basis for a generalization.

On the dome the "Big Lime" should be expected at about 375 feet below the top of No. 6 coal. The thickness through which the Ste. Genevieve has given production in other parts of the State is about 85 feet. A well should go about 100 feet into the lime to test this horizon. On the top of the dome where the surface elevation is about 610 feet and that of the coal 360 feet, this would require a hole approximately 725 feet deep.

NIAGARAN LIMESTONE AND HOING SAND

The next lower horizon where oil might be expected is in or under the Niagaran (Silurian) limestone. Under the "Big Lime" come the Kinderhook shales and the Devonian shales, followed by a limestone which is probably the Niagaran. In well No. 8, previously cited, the limestone at 1450 feet is doubtless Niagaran[1]. Near Carlinville the limestone at this horizon, encountered at 1395 feet, has a thickness of 340 feet. It is thought that most of this is Niagaran, although some Alexandrian might be expected. North of Edwardsville this limestone was encountered at 1450 feet and appears to be about the same thickness as at Carlinville. In Bond County and near Litchfield it is questionable if the limestone called "Trenton" is not more probably Silurian. Otherwise the Silurian limestone horizon at those places shows only 25 to 30 feet. This point introduces an element of doubt about the thickness of the Silurian at Staunton; however, it may be expected to be about 325 feet thick. As the Mississippian and upper Devonian rocks at well No. 8 are 850 feet thick, and at Carlinville 825 feet thick, the top of the Silurian limestone should be expected at about

[1] It is possible that some thickness of Devonian limestone may occur at the top of this limestone horizon. However, the correct corrlation of the upper part of the horizon is not pertinent to the discussion.

1475, and the bottom about 1800 feet below the surface in the S. ½ of section 14. Possibilities exist in the Niagaran limestone itself, and the "Hoing" sand of McDonough County comes immediately below the Silurian overlying the Maquoketa shale. Well records show that this sand is absent in many places in western Illinois, and also where present it is sometimes unproductive. However, this presents a possibility.

"TRENTON" LIMESTONE

The next and lowest likely oil horizon is that of the "Trenton" (Kimmswick-Plattin) limestone. The additional depth to the top of this limestone below the Silurian depends on the thickness of the Maquoketa shale. The Maquoketa is 165 feet thick at Jerseyville, about 180 feet thick at Carlinville, 130 feet, more or less, near Edwardsville, and either 75 or 190 feet at Litchfield (depending on uncertainties in correlation). The Maquoketa might be expected to be approximately 175 feet thick at Staunton. At Carlinville the "Trenton" was reached at 1914 feet and penetrated for 193 feet. Its physical characters were not promising for oil possibilities as it was a non-dolomitic limestone which seems to be the character of the upper portion of the "Trenton" generally in this part of the State. To test the "Trenton" a hole should go through the lower portion, which is in some places dolomitic, and therefore has more favorable physical characters. The "Trenton" is about 340 feet thick at Jerseyville, and 350 to 400 feet thick in Madison and St. Clair Counties. It may be expected to be about 400 feet thick at Staunton. A hole should reach the top of the "Trenton" at about 1975 and the bottom at approximately 2375 feet below the surface in the S. ½ of sec. 14.

CONCLUSIONS

The logical place for tests of the lower horizons would be well within the 360-foot contour on No. 6 coal—in the southern half of section 14.

In the following table, the first column gives the probable depths necessary to test the different underlying horizons in S. ½ sec. 14, Dorchester Township; the second column using No. 6 coal bears no relation to the surface elevation and therefore applies to the whole Staunton area.

Summary of probable depths to underlying horizons in S. ½ sec. 14, Dorchester Township

Horizon	Expected depth below surface	Expected depth below top of No. 6 coal
Top of "Big Lime"	625	375
Test of Ste. Genevieve limestone	725	475
Top of Silurian limestone	1475	1225
Test of Silurian and of Hoing sand horizon	1800	1550
Top of "Trenton" limestone	1975	1725
Test of "Trenton" limestone	2375	2125

SUMMARY

(1) The producing gas wells have followed very closely the structure, as shown by the contours on No. 6 coal, being influenced locally by the physical characters of the sand.

(2) The decline in gas pressure and flow has been very rapid and the present producing sands are nearing exhaustion in this locality.

(3) The sands have high porosity in places. They seem to be persistent, and if a doming similar to the known dome is found elsewhere in this general area, it may reasonably be expected to show the same horizon productive.

(4) Water has not so far been an important factor in the pool's decline. With the decrease of gas pressure the sand exposed to water is now more liable to be damaged.

(5) Too many wells are already tapping the present gas sand and no more wells should go after this gas in sections 10, 11, 12, 13, 14, 15, 22, 23, and 24 (with the exception of sec. 24 discussed above). The "oil show" horizon closely underlying the gas sand should be tested near the 360-feet coal contour. Lower possible oil horizons may be expected at depths indicated in the table given above under Conclusions.

ADDENDUM

Since the above paper was written, a location for a well given to Mr. M. F. Sherman of Staunton, on a lease held by him, resulted in the bringing in of a gas well at the SE. corner SW. ¼ SE. ¼ sec. 24. As shown under "Future drilling considerations," this general locality was the only one recommended for further gas-sand drilling. It is hoped that this area will be drilled carefully. Detailed logs of drilling in the following places will furnish information as to the "lay" of the beds: SE. corner SE. ¼ SE. ¼ sec. 24, NE corner SE. ¼ SE. ¼ sec. 24, SW. corner NE.¼ NE. ¼ sec. 25, all in Dorchester Township, and perhaps SE. corner SW. ¼ SW. ¼ sec. 19, Staunton Township. Subsequent drilling should depend upon the results of tests in these localities. Tests of this ground for shallow oil could then be located with greater assurance. As far as present knowledge goes, oil tests near the center SW. ¼ SE. ¼ sec. 24, or near the SE. corner NW. ¼ SE. ¼ sec. 24 seem worth while. A well to test for oil should be prepared to mud off any quantity of gas encountered, thus protecting the sands and making it practicable to go through the gas sand.

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE
STATE GEOLOGICAL SURVEY
FRANK W. DE WOLF, *Chief*

EXTRACT FROM BULLETIN NO. 44

OIL AND GAS DEVELOPMENT IN THE VICINITY OF JACKSONVILLE

BY
D. M. COLLINGWOOD

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OUTLINE

ILLUSTRATIONS

TABLE

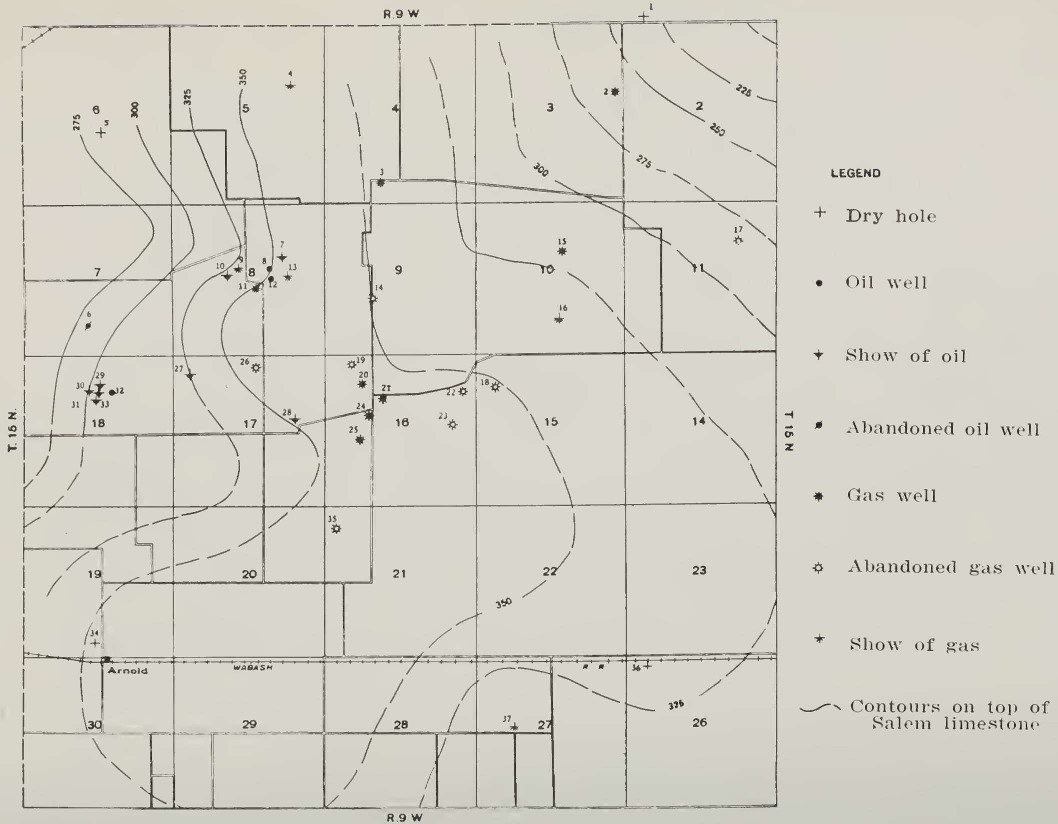


FIG. 1. Map showing contours on the eroded unconformable top of Salem limestone in the area few miles east of Jacksonville.

HISTORICAL REVIEW

An area of a few square miles about six miles east of Jacksonville, has in the past produced small quantities of oil and supplied gas for local consumption. In the spring of 1922 Mr. Frank Byrns of Jacksonville, who has always fostered the interest of the community in the development of this area, was instrumental in leasing a block of acreage to Messrs. Rhodes and Moorehead. After they began drilling operations other operators became interested and a general drilling program was undertaken.

In the past, approximately 35 wells (see fig. 1) had been drilled to a shallow pay horizon at about 300 feet, believed to be at the base of the Pennsylvanian or "Coal Measures" rocks. No detailed logs had been kept and those available were very unsatisfactory for geological correlation. The first new well was located close to one of the best of the original wells in the cen. S. ¼ SW. ¼ NE. ¼ sec. 8, T. 15 N., R. 9 W., which is reported still able to produce about a barrel a day. The new well was considered likely to be a small producer, but was abandoned because the casing fell back into the hole after the well was shot. Another well was drilled at the same location and was reported as being a 5-barrel well.

In response to numerous inquiries regarding deeper pay possibilities in this locality the State Geological Survey advised the operators that although two or three formations known to be oil bearing in other places in the State, would be found to a depth of 1500 feet in this area, they would not be expected to contain commercial quantities of oil unless a suitable structure or folding of the rocks was present. A deep test would not be advisable unless correlation of some persistent bed recognizable in tests to the shallow pay demonstrated the presence of favorable conditions, as for example an appreciable dome or a reversal of dip from the regional east dip, providing a closed structure. It was suggested that further tests, whether or not producing from the shallow horizon at the base of the Pennsylvanian, be drilled into the Mississippian, so that correlation might be made on a more uniformly recognizable bed, and also because the Mississippian structure is approximately parallel with the underlying formations in which the oil might be expected, while the Pennsylvanian strata are often not parallel with the older formations.

The Five Star Petroleum Company became interested in the area and further shallow drilling resulted in the finding of a gas well in the cen. NW. ¼ NW. ¼ SE. ¼ sec. 8, T. 15 N., R. 9 W., and of

a dry hole with a reported showing, located in the SE. cor. NE. ¼ SW. ¼ NE. ¼ sec. 8, T. 15 N., R. 9 W. Mr. Irwin also took up acreage, slightly deepened an old gas well at the cen. W. ½ SE. ¼ SW. ¼ sec. 4, T. 15 N., R. 9 W., and drilled two shallow gas wells, one in NE. ¼ sec. 10, and one in NE. ¼ sec. 3 of the same township. These two wells are believed to produce from the glacial drift rather than from the underlying consolidated rocks.

The available records of the old wells were very unsatisfactory and few had gone deeper than the first shallow pay horizon. No levels had been run to determine the surface elevation of those wells of which some record was available. The new wells drilled to the pay horizon or deeper, covered such a small area that there was still lacking the necessary information to prove or disprove the presence of an appreciably closed structure. Notwithstanding this, a deep test was decided on by Mr. Rhodes and associates. Without anything to guide the choice of its location beyond the production in the shallow pay, it was considered that owing to the regional dip being to the east, any structure represented in the underlying formations similar to structure in the shallow sand would probably be slightly offset to the west. A deep test located in the cen. S. ¼ SE. ¼ NW. ¼ sec. 8, T. 15 N., R. 9 W. was accordingly begun by a group of the business men of Jacksonville.

At this time it was possible for the Survey to investigate the area with a view to giving those interested the help and guidance possible from a proper interpretation of the data available, and thereby obtain the most economical method of furthering the proper exploration of the area in search for more and better production. The writer and party returning to headquarters from the field work of the regular season's program in the western part of the State were enabled to visit this area in November. As no outcrops in the area were visible due to the low topographic relief of the area, all structural information was dependent upon subsurface records. Levels were run to all the old and new wells of which some record was available, although in most cases the only information obtainable was the depth to the "rock" or depth to the pay horizon. It was evident that a close study and correlation of these depths together with the detailed logs of the recent wells represented the only data from which to attempt a detailed interpretation of the existing geological conditions.

LOGS OF WELLS IN THE JACKSONVILLE AREA

The following logs compiled mainly from studies of samples kept by those persons responsible for the recent drilling, show the nature of the formations penetrated:

Log from study of samples from Rhodes and Moorehead Well No. 2 located on Mahon farm in SW. ¼ NE. ¼ sec. 8, T. 15 N., R. 9 W.

Elevation—591.7 feet

Sample No.		Thickness *Feet*	Depth *Feet*
	Pennsylvanian system		
1.	Shale, light gray	13	125
2.	Sandstone, very fine grained, gray, well cemented	5	130
3.	Same as above	5	135
4.	Sandstone, shaly, otherwise as above	5	140
5.	Shale, sandy, as above but with more shale and not well cemented	5	145
6.	Shale, light gray-brown	9	154
7.	Shale, black, hard	3	157
8.	Limestone and shale, dark, with some iron pyrites	5	162
9.	Shale, light gray-brown	8	170
10.	Limestone, dark grey and white, interbedded	6	176
11.	Same as above	5	181
12.	Limestone as above with some shale, light to dark, hard	5	186
13.	Sandstone, fine grained, white, loosely cemented	5	191
14.	Shale, light brown-gray	5	196
15.	Shale, hard, medium grained	5	201
16.	Shale with some limestone and iron pyrites and few fragments of coal	4	205
17.	Coal and shale	5	210
18.	Shale, light and dark with coal, probably cavings	5	215
19.	Shale, gray	5	220
20.	Shale, gray, with probably lime concretions	5	225
21.	Conglomerat, mostly mixed shales, various colors, little sand and iron pyrites	5	230
22.	Conglomerate, with more sand, white, grains fine, fairly well rounded, poorly cemented	5	235
23.	Sandstone grains, poorly sorted, but fairly well rounded, poorly cemented	5	240
	Unconformity		
	Mississippian system		
	Salem formation		
24.	Same as No. 23 with some light yellow fragments of well cemented fine grained sandstone	2	242
25.	Sandstone, light yellow (some gray), well cemented, fine grained, hard, non-calcareous grit stone, two samples (1) gray (2) light yellow	4	246

Log from study of samples from Rhodes and Moorehead Well No. 2—Concluded

26.	Sandstone, coarse grained, well rounded and sorted, loosely cemented	4	250
27.	Sandstone, two samples (1) fine grained, well cemented, light yellow and gray; (2) coarse grained, loosely cemented, fairly well rounded and sorted, grains white with some white chert	4	254
28.	Sandstone, coarse grained, loosely cemented, white as above passing below to dense white limestone	4	258
29.	Two samples about same horizon, (1) sandstone, coarse grained, mixed with chert, loosely cemented	5	263
	(2) sandstone, coarse, poorly cemented, good looking oil sand stained yellow, some smell of oil	7	265
30.	Sandstone, chunks of oil sand, medium grained, poorly cemented, stained with oil, also chunks of banded and irregular chert, brownish to whitish —all probably emitted by shot	5	268
31.	Sandstone and chert, as above	5	273

Log from study of samples from Rhodes and Moorehead Well No. 3 (Five Star Petroleum Company well No. 1) located on Coons farm in NW. 1/4 SE. 1/4 sec. 8, T. 15 N., R. 9 W.

Elevation—615.8 feet

Sample No.		Thickness *Feet*	Depth *Feet*
	Pennsylvanian system		
1.	Shale, dark gray, slightly gritty	5	145
2.	Shale, black with little coal	5	185
3.	Coal, with little sandstone well cemented, fine grained	5	190
4.	Limestone, impure, light gray	5	195
5.	Same as above	5	200
6.	Limestone, grading to shale, gray, below	5	205
7.	Shale, dark brown, and limestone, gray interbedded	5	210
8.	Shale, light gray	5	215
9.	Shale, light gray to medium dark gray	5	220
10.	Sandstone, very fine grained, light gray, micaceous, and argillaceous, loosely cemented	5	225
11.	Sandstone, fine grained, well rounded, well sorted, gray, micaceous, loosely cemented	5	230
12.	Shale, light brown to gray, (yellow stained), with coal	5	235
13.	Three samples: (1) Coal with little shale, light brown to gray... (2) Coal with little clay, light gray, and shale.. (3) Shale and clay	5	240

Log from study of samples from Rhodes and Moorehead Well No. 3—Concluded

14. Sandstone, fine grained, well cemented, light gray with few fragments of coal, probably cavings.....	5	245
15. Sandstone, impure, conglomeratic, fine grained, poorly cemented, light yellow to gray, some limestone and some mica........................	5	250
16. Sandstone, white, medium grained, pure, poorly cemented, well rounded, not very well sorted.....	5	255
17. Sandstone, white, coarser grained, well rounded, not so well sorted, interbedded with some shale..	5	260
18. Sandstone, white, medium grained, well rounded, poorly sorted with little shale and chert.........	5	265
Unconformity		
Mississippian system		
Salem—Warsaw formation		
19. Limestone, white to yellowish gray, hard, dense....	5	270
20. Limestone, same as above, interbedded with limestone, sandy, light yellow stained..............	5	275
21. Limestone, same as above, with little limestone, sandy	5	280
22. Limestone, white, dense, pure, hard...............	5	285
23. Limestone, same as above........................	5	290
24. Limestone, white, dense, and limestone, earthy, and sandy, light yellow............................	5	295
25. Limestone, white, dense, and limestone, sandy, pale brown to gray................................	5	300
26. Limestone, slightly sandy, white to light gray......	5	305
27. Limestone, white to brown, sandy to dense, slightly crystalline	5	310
28. Sandstone, calcareous, white to light gray, hard, well cemented, little iron pyrites...............	5	315
29. Limestone, light brown-gray and white, grading to sandstone, calcareous, light brown-gray to white, well cemented, little iron pyrites...............	5	320
30. Sandstone, calcareous, gray, grading to limestone, sandy, well cemented, hard, some pure sandstone with large quartz grains......................	5	325
31. Sandstone, calcareous, light gray, and shale, light blue-gray, hard	5	330
32. Same as above, some disseminated iron pyrites in the sandstone	5	335
33. Shale, sandy, light blue-gray, and limestone, sandy, white, to light gray..........................	5	340
34. Shale, sandy, light blue-gray and sandstone, calcareous, fine grained, well cemented, hard, white to light gray................................	5	345
35. Shale, gritty, and calcareous, hard, blue-gray.......	5	350
36. Limestone, shaly, and sandy, blue-gray, medium hard	?	350

Log from study of samples from Rhodes and Moorehead well No. 4 (Five Star Petroleum Company well No. 2) located on Mahon farm in SW. ¼ NE. ¼ sec. 8, T. 15 N., R. 9 W.

Elevation—597.2 feet

Sample No.		Thickness *Feet*	Depth *Feet*
	Pennsylvanian system		
1.	Shale, black, and coal with sulphur (iron pyrites) bands	5	174
2.	Missing	5	179
3.	Limestone, light and dark gray, dense to fine grained	5	184
4.	Limestone, gray above to white below	5	189
5.	Sandstone, shaly, very fine grained, gray, hard, some fine grained mica	6	195
6.	Shale, grading from shale, sandy, light gray above to shale, gray, pure, below	5	200
7.	Shale, dark brown-gray, hard	5	205
8.	Shale, dark, brown-gray, hard, above grading to shale, sandy, gray, hard, below	5	210
9.	Shale, gray, soft, with shale, gritty, interbedded	5	215
10.	Shale, gray, soft, and coal	5	220
11.	Shale, gray, soft, slightly gritty, and clay	5	225
12.	Coal and shale, brown-gray, soft, coal possibly cavings from above	5	230
13.	Shale, brown-gray, small amount of coal and brown bituminous partings	11	241
14.	Shale, light and dark gray, soft to hard, some chert and sand grains	5	246
	Unconformity		
	Mississippian system		
	Salem (and Warsaw?) formations		
15.	Limestone, dense, hard, earthy, dull, light yellowish gray	4	250
16.	Limestone, sandy, light gray to white with limestone, hard, impure interbedded	5	255
17.	Limestone, sandy, light gray	5	260
18.	Limestone, sandy, white, thin bedded above and shale, brown-gray, hard below	5	265
19.	Limestone, light yellow to white, dense, hard	5	270
20.	Same as above	3	273
21.	Same as above	5	278
22.	Limestone, same as above, and limestone, sandy, gray, hard below	5	283
23.	Missing	5	288
24.	Limestone, sandy, gray, hard	5	293
25.	Limestone, sandy, gray, hard, above grading to sandstone, calcareous, light yellow, hard below	5	298

Log from study of samples from Rhodes and Moorehead well No. 4—Concluded

26.	Shale, green, hard, and limestone, sandy, sandstone, calcareous, with little calcite (297-302)	5	302
27.	Sandstone, calcareous, green, and limestone, sandy, white	4	306
28.	Limestone, sandy, gray to white, with few large quartz grains, a little chert and some iron pyrites	7	313

RELATION OF PAY HORIZON TO UNCONFORMITY AT TOP OF THE MISSISSIPPIAN

It is apparent that the pay is found in the top of the Mississippian, which, in this area, is the Salem (Spergen) formation. It is a sandy limestone, grading into a calcareous or limy sandstone. Possibly the drillers of the old wells were unable to distinguish between the limy sandstone and the sandy limestone, and in most cases compromised by calling it "rock." Based on this assumption, correlations of the top surface of the Mississippian have been made in many cases from old records that gave depth only to the "rock" or top and bottom of the pay in the "rock."

Above the Mississippian formations are found beds of Pennsylvanian age, but the immediate bed or sequence of beds above the Mississipian top is not always the same, even in neighboring locations. An interval of time is known to have occurred between the deposition in marine waters of the Mississippian formations, and the later deposition of the Pennsylvanian sediments. In this time interval the Mississippian rocks became elevated with regard to the seas, and were subjected to weathering agencies and eroded. Subsequently, this old land surface again became submerged followed by the deposition of the sands, muds, peats, etc. which have become the Pennsylvanian or "Coal Measures" rocks. The first Pennsylvanian sediments would be laid down on an uneven surface—in this case the eroded surface of the sandy Salem limestone. Such a relation is known as an unconformity.

Sedimentation on the higher portions of this old surface might not begin until the lower places had been filled, but even if the sediments were laid down simultaneously on higher and lower areas, they would differ in character, due to the different conditions of sedimentation in shallow and deep waters. The detailed physiography of such an eroded surface would depend on the character, intensity, and duration of the erosional period, but the broader aspects of the contours of this surface might bear a distinct relation to the folding shown in the rock strata beneath. Folding, giving rise to relative elevations of

certain areas, would be responsible for subjecting those areas to erosional agencies, which however, do not often completely wear down those elevations before regional depression and sedimentation again take place.

The Pennsylvanian sediments in this area were thus laid down on the tilted, slightly folded and eroded surface of the Mississippian strata. Subsequent consolidation of the sediments and continued depression towards central Illinois have caused further tilting towards the east, possibly accompanied and followed by folding involving both Pennsylvanian and Mississippian strata. As a general result, the easterly dips of the Pennsylvanian strata are less in degree than those of the Mississippian.

The oil and gas east of Jacksonville have been found mostly in certain lenses or horizons in the Salem, and are associated with the highest parts of its old eroded surface. The surface has been exposed to the weathering agencies and rendered porous by the solution of the lime in which the sand grains are imbedded. In some cases this has been accompanied by a partial silicification of the rock followed by further leaching of the lime which seems to have developed further porosity along bedding planes. The sandy lime is thus porous in spots and along certain channels. These have afforded reservoirs for oil accumulation subsequently when buried by later sedimentary strata. The Pennsylvanian strata capping the high spot in the Salem have provided the impervious cap insuring retention of the oil. Thus, in effect, we have something similar to an anticlinal dome known as an "erosional high," a structure not necessarily due to any folding.

The higher beds of the sandy Salem limestone show variation laterally in sand content, porosity, and degree of weathering. This accounts for the accumulation of the oil and gas in different lenses in the rock and not in continuous layers. In general, however, the oil and gas have been found in the top of the Salem where it forms an old "erosional high" area of the Mississippian formation. Figure 1 shows approximately the high area of this surface by means of contours representing 25-foot intervals based on the records of the wells which are tabulated in Table I. The most probable interpretation made on the meager data available is given as the best guide until more detailed information is obtained. To the east of this high area it is known that the Salem surface dips to the east in response to both pre-Pennsylvanian and later movements which have resulted in the relative depression of all the rock formations in central Illinois. The west slope of the top of the Salem appears to be well defined in secs. 5, 6, and 7, T. 15 N., R. 9 W., the rate and amount of the slope deter-

mined being controlled by the interpretation of the data available from the O. H. Cully and E. O. Green wells in secs. 6 and 7. However, these records are so poor that the present interpretation must be taken as only tentative. The slope of the Salem to the west is a reversal of the surface slope to the east which follows the direction of the regional dip of both the Pennsylvanian and Mississippian strata, and results in an elongated area of high Salem along the common line of secs. 4 and 5 and south between secs. 8 and 9, including the SE. ¼ sec. 8, T. 15 N., R. 9 W. It is tentatively suggested that this high area continues southward and westward as a dome including the area enclosed by the 350-foot contour (fig. 1). No detailed structural information of the area between secs. 6 and 7, T. 15 N., R. 9 W. and Jacksonville is available, but from Jacksonville to the west it is known that both the Mississippian strata and the locally irregular Salem surface continue to rise towards the west, and formed a land barrier to the invading sea of the Pennsylvanian in its overlapping encroachment from the east.

GEOLOGICAL STRUCTURE AND PRODUCTION POSSIBILITIES

The possible oil-bearing horizons in this area are:

1. Pennsylvanian sandstones at shallow depths from approximately 100 to 250 feet.
2. Mississippian top, Salem, sandy limestone at a depth varying from 200 to 565 feet.
3. Keokuk-Burlington, cherty limestone with some porous horizons, at a depth varying from 415 to 780 feet.
4. Devonian top (Hamilton?), thin sandstone and limestone, at a depth varying from 847 to 1300 feet.
5. Ordovician, Kimmswick-Plattin, or "Trenton" limestone, at a depth varying from 1240 to 1700 feet.

Pennsylvanian Strata

The Pennsylvanian or "Coal Measures" contains some sandstone members which might be considered as likely reservoirs for oil accumulation, but a favorable structure is a prerequisite for its retention. The tendency to buckle exhibited by the older rocks at certain places where the crustal stresses are relieved is also transmitted to the younger formations above. Any appreciable folding of the Pennsylvanian strata in Illinois has usually been found immediately over folding in the Mississippian and older rocks, but the degree of deformation is less. The movements during or after Pennsylvanian time have therefore as a rule provided gentle folds in the Pennsylvanian, while intensifying those in the Mississippian.

TABLE 1.—*Tabulated data on bor-*

Index No.	Farm	Location			
		T. N.	R. W.	Section	Part of section
1	O'Rear, Judge	16	9	35	cen. S. ¼ SW. ¼ SE. ¼
2	Harris (Irwin)	15	9	3	cen. E. ¼ SE. ¼ NE. ¼
3	Rayburn	15	9	4	SW. ¼ SE. ¼ SW. ¼...
4	Effie & Laura Green	15	9	5	cen. W. ¼ SE. ¼ NE. ¼
5	Cully	15	9	6	cen. E. ¼ NE. ¼ SW. ¼
6	Green, E. O.	15	9	7	cen. N. ¼ SE. ¼ SW. ¼
7	Five Star Petroleum Company No. 2 (Rhodes & Moorehead No. 4)	15	9	8	cen. E. ¼ SW. ¼ NE. ¼
8	Mahon (old well No. 1)	15	9	8	cen. S. ½ SW. ¼ NE. ¼
9	McCleary (old well)	15	9	8	SE. ¼ SE. ¼ NW. ¼...
10	McCleary (Community or Rhodes No. 5)	15	9	8	cen. S. ¼ SE. ¼ NW. ¼
11	Coons (Five Star Petroleum Company No. 1 or Rhodes and Moorehead No. 3)	15	9	8	NW. ¼ NW. ¼ SE. ¼..
12	Mahon (Rhodes & Moorehead No. 2)	15	9	8	cen. S. ¼ SW. ¼ NE. ¼
13	Mahon (old well No. 2)	15	9	8	SW. ¼ SE. ¼ NE. ¼...
14	Curtis, Margaret No. 2	15	9	9	cen. W. ¼ NE. ¼ SW. ¼
15	O'Rear, T. B. (Irwin)	15	9	10	cen. W. ½ SW. ¼ NE. ¼
16	O'Rear, T. B. (old well)	15	9	10	E. ½ SW. ¼
17	Robertson	15	9	11	cen. NE. ¼
18	O'Rear, Nettie	15	9	15	cen. S. ¼ NW. ¼ NW. ¼
19	Curtis, Margaret No. 1	15	9	16	cen. N. ½ NW. ¼ NW. ¼
20	Tindall, Isaac No. 4?	15	9	16	SE. ¼ NW. ¼ NW. ¼..
21	Tindall, Isaac No. 3	15	9	16	cen. N. ½ SE. ¼ NW. ¼

ings in the vicinity of Jacksonville

Elevations above sea level					Remarks
Curb	Coals	Pennsylvanian sandstones	Base of Pennsylvanian and top of Mississippian (Salem limestone)	Pay in Salem sandy limestone	
643	....	293 (gas)	227	....	Dry
645	....	....	....	....	Production of drift gas
642	....	....	344	337	Gas (Deepened by Irwin et al)
647	....	384?	371	342	Show of gas; abandoned
628	....	....	283	....	Dry
592	....	344?	287	....	Production of oil; abandoned
597	426 371	408	351	311	Show of oil; abandoned
591	....	....	345	328	Production of oil
588	....	....	393	393	Show of gas; abandoned
589	421 371	....	335	335	Show of oil; Trenton test
616	431 381	396 376	351	351	Production of gas, show of oil, gas at 361 feet
592	439 387	467 406 362	352	332	Production of oil
592+	....	....	256+	....	Abandoned
638	....	....	350+	350	Production of gas; abandoned
600	....	....	....	....	Production of drift gas
600+	....	....	340+	300+	Show of gas; abandoned
....	....	....	....	....	Production of drift gas; abandoned
641	....	....	351	347	Show of gas; abandoned
630	....	....	375	375	Production of gas; abandoned
639	....	....	357+	357+	Production of gas
643	....	357	357 or 350	356	Production of gas; abandoned

TABLE 1.—*Tabulated data on borings in*

Index No.	Farm	Location			
		T. N.	R. W.	Section	Part of section
22	Tindall, Isaac No. 2......	15	9	16	cen. E. ½ NE. ¼.......
23	Tindall, Isaac No. 1......	15	9	16	SW. ¼ SE. ¼ NE. ¼...
24	Green, Scott B...........	15	9	16	SW. ¼ SE. ¼ NW. ¼...
25	Hemphill	15	9	16	NE. ¼ NW. ¼ SW. ¼..
26	Coons, C. M. (old well)...	15	9	17	NW. ¼ NW. ¼ NE. ¼..
27	Dunlap	15	9	17	cen. NW. ¼ NW. ¼.....
28	Green, J. M..............	15	9	17	SW. ¼ SE. ¼ NE. ¼...
29	Davies No. 2.............	15	9	18	cen. E. ½ SE. ¼ NE. ¼ NW. ¼ ....
30	Davies No. 4.............	15	9	18	SW. cor. SE. ¼ NE. ¼ NW. ¼ ....
31	Davies No. 1.............	15	9	18	SE. cor. SE. ¼ NE. ¼ NW. ¼ ....
32	Davies No. 5.............	15	9	18	SE. cor. SE. ¼ NE. ¼ NW. ¼ ....
33	Davies No. 3.............	15	9	18	cen. N. ½ NE. ¼ SE. ¼ NW. ¼ ....
34	Arnold	15	9	19	SE. ¼ SE. ¼ SW. ¼....
35	....?....................	15	9	21	cen. W. ¼ NW. ¼ NW. ¼ ....
36	Strawn	15	9	26	cen. N. ½ NW. ¼ NW. ¼ ....
37	Drury	15	9	27	cen. W. ½.............
38	Tindall, E. M.[1]...........	15	9	32	SW. ¼ ....
39	Wilcox[1] (Ohio Oil Co.)....	15	8	16	....
40	Snyder Ice Company[1].....	15	10	16	....

[1] Located outside map shown in figure 1.

the vicinity of Jacksonville—Concluded

Elevations above sea level					
Curb	Coals	Pennsylvanian sandstones	Base of Pennsylvanian and top of Mississippian (Salem limestone)	Pay in Salem sandy limestone	Remarks
638	....	....	353 (gas)	321	Production of gas; abandoned
643	....	366	366 or 343	366	Production of gas; abandoned
635	....	....	369	369	Production of gas
638	....	....	359	359	Production of gas
605	....	391 (gas)	360	....	Gas; abandoned
623	....	....	320	303	Show of oil; abandoned
635	....	386	332+	332	Show of oil; abandoned
610	....	{342 330 (oil)	307	....	Show of oil; abandoned
599	427	324	303	303	Show of oil and gas; abanoned
596	....	....	....	....	Abandoned
596	....	....	316+	316	Production of oil
600	....	....	324+	324	Production of oil; abandoned
634	....	....	354	....	Dry
634	....	....	334+	334+	Production of gas; abandoned
655	....	....	335	....	Dry
653	....	....	303	295	Show of gas; water well
630±	....	....	330±	....	Dry
670±	{390± 300±	{460± 335±	230±	....	Dry
597	442	....	425?	....	Water well

A detailed contouring of the Pennsylvanian structure or folding based on the correlation of a certain coal which has been reported rather frequently in logs of wells in the vicinity of this particular area has been attempted. Figure 2 shows contours drawn on this coal, but they can be considered as tentative only. Not only were the logs scarce and imperfectly kept, but some wells were not close enough together to enable exact correlation, and as it was not possible to run levels to all of these holes in the limited time available, in some cases the elevations had to be estimated from comparison with railroad levels.

Carefully kept logs and samples of any further drilling in this area will materially add to the data necessary for checking or modifying the contours as suggested in figure 2. There is apparently a slight closure in the Pennsylvanian represented by the 425-foot contour in T. 15 N., R. 9 W. which shows in the east part of the township a reverse or west dip in contrast with the normal regional dip to the east. The higher area of this structure in the Pennsylvanian probably coincides approximately with the shape of the high erosional area of the underlying Salem.

No production seems to have been maintained at any time from Pennsylvanian sandstones in this area although in a few cases, owing to a shale break at or near the bottom of a basal Pennsylvanian sandstone, gas and oil shows and some gas production have been obtained. The Salem sandy lime or "gritstone" seems to have afforded greater facilities for oil accummulation and retention. In some cases notably in the Five Star Petroleum Company's well No. 1 (Rhodes and Moorehead No. 3) where a pure Pennsylvanian sandstone lies directly on the Salem sandy lime, neither oil and gas nor water was found in the former, but gas was found in the top of the latter, and oil under pressure of water saturation a little deeper. No shale bed was evident between the two in either the driller's record or the samples of drill cuttings to explain how the gas remained in the Salem without passing up into the porous sandstone above. A small percentage of chert was found in the sample of the first screw in the Salem, and it is possible that a completely silicified and impervious bed of chert may have been deposited by secondary action along the unconformity between the Pennsylvanian and the Mississippian which serves as a cap rock to the gas in the rock below. Also perhaps a thin bed of shale at the base of the Pennsylvanian sandstone might have been penetrated by the drill without showing up in the washed sample and yet be thick enough to form an impervious cap to oil and gas contained below. Generally,

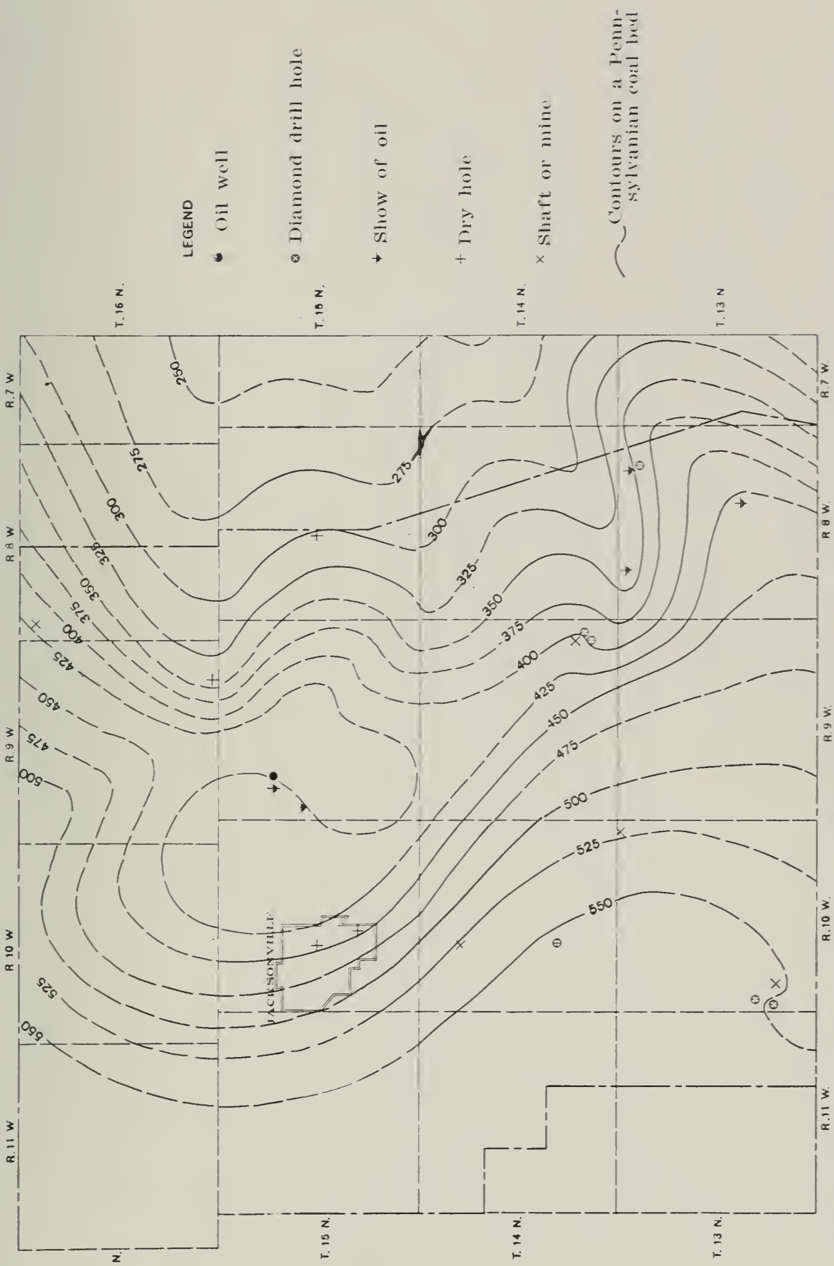


FIG. 2. Structure of Pensylvanian strata in the vicinity of Jacksonville based on a tentative coal correlation.

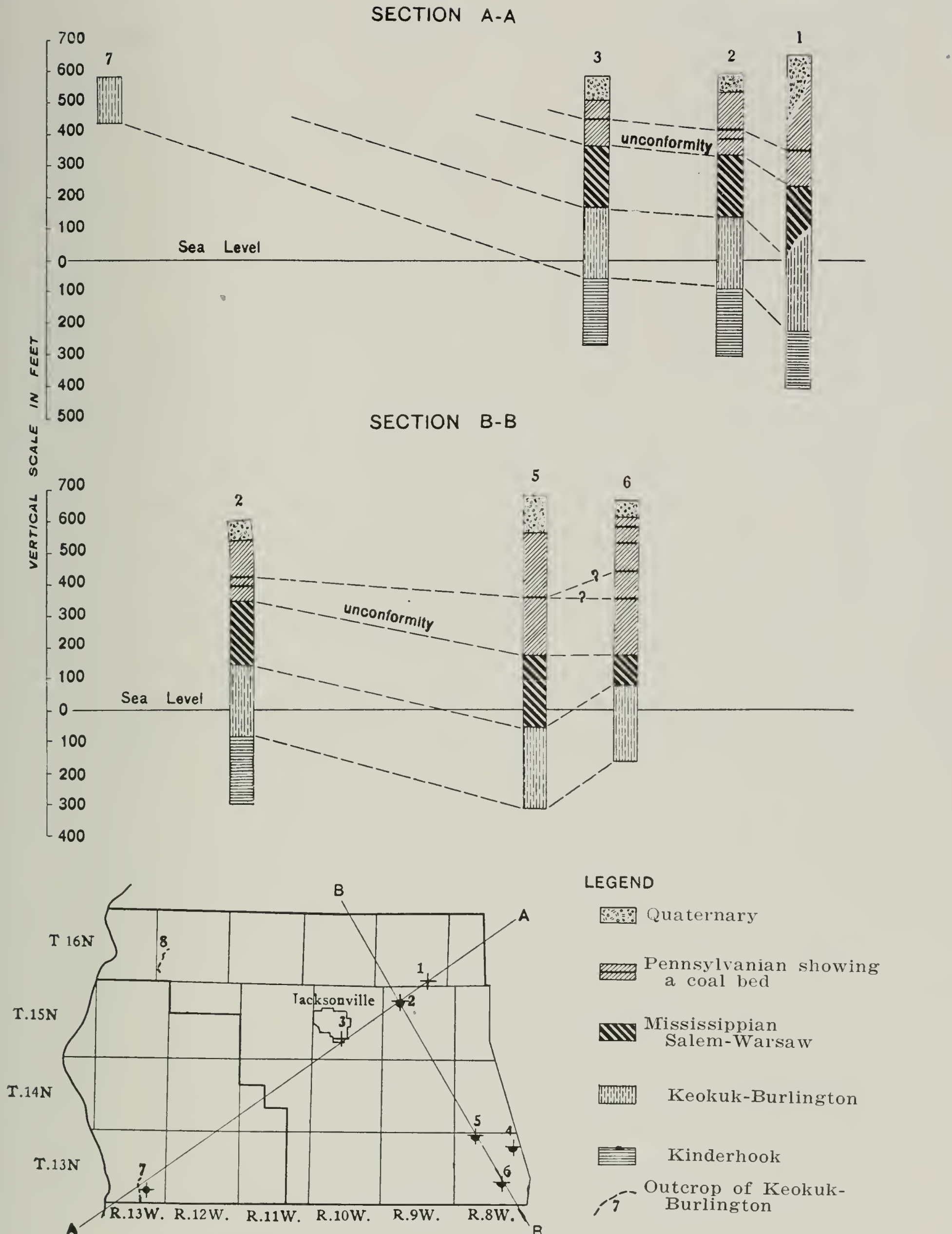
however, the basal Pennsylvanian formation is a shale which affords an impervious capping to the oil contained in the porous lenses of the Salem sandy limestone beneath it.

Mississippian and Older Strata

The top surface of the Salem represents an unconformity and its configuration may be altogether the effects of erosion between Mississippian and Pennsylvanian time. It has been observed in Illinois, however, that often the present higher areas of the old Mississippian surface owe their elevation partly to folding or upwarping of the Mississippian and underlying formations. They are, therefore, indicative not only of erosional effects but also of structural deformation in the underlying formations. However, the slope of the eroded surface will not necessarily be any index of the amount of dip of the fold. The structure existing in the Mississippian and underlying formations can only be suggested, due again to the scarcity of wells drilled to sufficient depth in this and the surrounding area, but it is more or less similar to the structure on the base of the Keokuk-Burlington formations as shown in the cross sections in figure 3.

In addition to the shallow Salem pay, there are the possibilities of pay horizons in the Keokuk-Burlington limestone, Devonian sandstone and limestone, and Trenton limestone. The Keokuk-Burlington is a cherty limestone in which water is often found in channels and porous irregular veins. Very rarely is oil found in these formations, but the two wells in secs. 2 and 5, T. 13 N., R. 8 W. had shows of oil near the top and also towards the bottom of the formation. Figure 3 shows the locations of the wells of which some record to the base of the Keokuk-Burlington limestone has been obtained. The cross sections A-A, and B-B show that there is marked irregularity at least in the regional dip of the formations. A dip of 45 feet to the mile is shown between the Judge O'Rear well in sec. 35, T. 16 N., R. 9 W. and the Community (Rhodes and Moorehead No. 5) well in sec 8, T. 15 N., R. 9 W. while between the latter and Jacksonville the total regional rise is only 30 feet in 5¾ miles suggesting a marked terrace. Information regarding a possible structural similarity of the Mississippian and Pennsylvanian rocks both in degree of deformation and in location of the axis of any closure on this terrace can be obtained only by drilling.

Immediately below the Sweetland Creek chocolate shale the Devonian in this area may include a thin sandstone only a few inches thick. Underlying this there are siliceous limestone beds which are locally more or less porous due probably to weathering and circulating ground waters associated with an unconformity. This zone immedi-



1. Judge O'Rear well
2. Rhodes et al.—Cleary well
3. Jacksonville City well
4. J. W. Tomb well
5. Hughes-Procter well
6. Geo. McDivett No. 2 well
7. Outcrop
8. Outcrop

FIG. 3. Cross sections showing the structure of Pennsylvanian and Mississippian strata in the Jacksonville area.

ately below the chocolate shale has showed oil in many places in central and western Illinois. If the thin sandstone is present or the limestone is found porous on a closed structure this horizon has possibilities as a producer, but heretofore in central and western Illinois a good show of oil has often been obtained followed immediately by salt water, on drilling a few inches further.

The pore spaces seem so great that oil possibly originally accumulated therein has now been replaced by water under probably different conditions of circulation and capillarity. The Community well (Rhodes and Moorehead well No. 5) in sec 8, T. 15 N., R. 9 W., and the McDivett No. 2 well in sec. 22, T. 13 N., R. 8 W. both had oil shows near the top of this Devonian sand and siliceous limestone.

During the summer of 1922, after the five shallow tests had been put down all within a few hundred feet of one another, the Survey was asked to recommend a good location for a deep test to the Trenton. In the absence of any further information on structure, it was advised that preferably only shallow tests be drilled until the extent of the shallow structure were known and the highest point of the structure determined by correlating a Pennsylvanian, or if possible, some Mississippian bed. However, the operators found it desirable to drill to the Trenton in the SE. ¼ NW. ¼ sec. 8, T. 15 N., R. 9 W. This was a dry hole, but had a show of oil at 897 feet, beneath the chocolate Sweetland Creek shale which was followed immediately by salt water. A show (mostly smell) was also reported in the Trenton.

The log of this boring is as follows:

Jacksonville Community Well No. 1 (Rhodes and Moorehead Well No. 5) located on Cleary farm in SE. ¼ NW. ¼ sec. 8, T. 15 N., R. 9 W.

Elevation—588.5 feet

Driller's log to a depth of 655 feet

	Thickness *Feet*	Depth *Feet*
Quaternary and Pennsylvanian systems		
Soil, black	3	3
Clay, yellow	13	16
Gravel with water	1	17
Clay, blue	43	60
Shale, gray	88	148
Slate, light	20	168
Coal	3	171
Shale, gray	5	176
Lime, gray, hard	10	186
Slate, light	19	205

Jacksonville Community Well No. 1—Continued

Shale, dark, gas show, coal seam	15	220
Slate, light	15	235
Shale, red	10	245
Slate	9	254
Unconformity		
Mississippian system		
Salem and Warsaw formations		
Lime, hard (oil show)	19	273
Lime, hard (set 10 in. casing at 283)	35	308
Shale, blue	7	315
Lime, gray	10	325
Lime, gray	15	340
Lime, brown	10	350
Lime, white	5	355
Broken lime	45	400
Shale, blue	33	433
Shale, gray	19	452
Keokuk-Burlington formation		
Lime, gray, hard	48	500
Lime, white, hard, sharp, and settles quickly	155	655

Log from study of samples from 510 to 1390 feet [a]

	Thickness *Feet*	Depth *Feet*
Keokuk-Burlington formation		
Limestone, white to light gray, dense to granular, and chert, white	5	515
Same as above	5	520
Same as above	5	525
Same as above	5	530
Same as above	5	535
Limestone, white to light gray, granular, dull to crystalline, hard; chert, gray to white	5	540
Same as above	5	545
Same as above	5	550
Limestone, white to gray, granular, dull to crystalline, hard, little chert	5	555
Same as above	5	560
Same as above	5	565
Limestone, gray to flesh colored, dull to crystalline, hard, and little chert	7	572
Limestone, gray to flesh colored, crystalline, hard	5	600
Limestone, flesh colored to light buff, crystalline, hard, with little chert, white to gray	4	604
Same as above	5	609
Limestone, gray to flesh colored, crystalline, hard	5	614
Limestone, gray to light buff, granular, dull to crystalline; chert, white to gray	5	619

Jacksonville Community Well No. 1—Continued

Missing, believed to be same as above	51	670
Limestone, crystalline, passing below to shale, light blue, hard	5	675
Kinderhook formation		
Shale, light blue, hard	5	680
Missing, believed to be same as above	53	733
Shale, blue-gray, hard	6	739
Same as above	8	750
Same as above	55	805
Sweetland Creek formation		
Shale, chocolate, soft to hard, disseminated grains of iron pyrites and Sporangites	5	810
Shale, same as above	22	850
Same as above	5	855
Shale, chocolate, hard, disseminated grains of iron pyrites and Sporangites	10	860
Shale, same as above	5	865
Shale, blue-gray above, and limestone, granular, crystalline, white to gray, hard below; some fragments of calcite, iron pyrites, shale, green, and few sand grains	7	892
Devonian and Silurian systems		
Limestone, white, granular, crystalline, hard with few calcite and sand grains	6	898
Limestone, white, granular, crystalline, hard	2	900
Same as above	9	909
Same, with few sand grains	5	914
Same	4	918
Limestone, white, sandy, hard, granular, somewhat rounded grains, finely crystalline, few sand grains, probably from above	3	921
Limestone, sandy, same as above	5	930
Limestone, sandy, same as above with a hard shale parting and some chert	5	935
Limestone, white, sandy, hard, granular, somewhat rounded grains, finely crystalline, few grains of chert, sand and pyrite	5	940
Sandstone, medium, well rounded quartz grains moderately well sorted with few smaller grains	4	947
Limestone, sandy, as before, white, hard, granular, rounded grains; finely crystalline, with few sand grains andpyrite	4	951
Sandstone, medium, well rounded quartz grains; varying sizes	5	955
Sandstone, same as above, but rather well sorted; some limestone similar to last above	6	960
Sandstone, limy, medium well rounded quartz grains, varying sizes, some limestone similar to last above	4	966
Sandstone, limy, same as above	5	973
Shale, green, soft, some limestone, red, hard, granular, finely crystalline	5	973

Jacksonville Community Well No. 1—Continued

Sandstone and limestone, sandy, interbedded sandstone, somewhat unsorted, medium grained limestone, white, hard, granular, finely crystalline	4	977
Limestone, sandy, white, hard, sub-crystalline to dense, limestone, less sandy than above	3	980
Limestone, sandy, same as above	4	984
Limestone, sandy, white, finely crystalline, some granular.	5	990
Limestone, sandy, white, finely crystalline, granular, more sandy than above	5	995
Limestone, sandy, white, finely crystalline, and granular..	5	1000
Limestone, sandy, white to gray, dense to crystalline	6	1006
Limestone, sandy, white, dense to light blue-gray, crystal line	4	1010
Limestone, sandy, white to gray, finely crystalline to sub-crystalline and dense	6	1018
Limestone, sandy, same as above	3	1021
Limestone, sandy, white, same as above with about 50 per cent chert, white	5	1026
Limestone, sandy, same as above	5	1031
Limestone, sandy, same as above	5	1036
Limestone, sandy, white-gray, dense to finely crystalline, some limestone, brownish-gray, more crystalline; some chert, few green partings	5	1041
Limestone, sandy to dense, white to yellow, with some pyrite grains and chert, shale, blue-gray, hard, about 25 per cent	5	1046
Ordovician system		
Maquoketa formation		
Shale, blue-gray, softer	5	1051
Shale, same as above	5	1056
Shale, blue-gray, harder, slightly calcareous	5	1061
Same as above	2	1063
Shale, blue to dark gray, hard, slightly calcareous at 1061	..	1061
Shale, dark green-gray, softer, slightly calcareous at 1072	..	1072
Shale, blue-gray, medium hard, slightly calcareous	5	1077
Shale, green-gray, soft, slightly calcareous	5	1082
Shale, same as above	5	1087
Same as above	5	1092
Same as above	7	1099
Shale, blue-gray, hard, slightly calcareous	4	1103
Shale, blue-gray, medium hard, slightly calcareous	5	1108
Shale, dark brown-gray, soft, slightly calcareous	5	1113
Shale, blue-gray, medium hard, slightly calcareous	6	1119
Shale, gray, medium hard, slightly calcareous	5	1124
Shale, dark brown, hard	6	1130
Shale, dark brown, hard, few pyrite grains	5	1135
Shale, dark brown, hard, and limestone, impure, white to gray, about 50 per cent	5	1140

Jacksonville Community Well No. 1—Concluded

Limestone, impure, white to blue-gray and shale, gray, hard, about 50 per cent	6	1146
Shale, blue to greenish gray, medium hard, calcareous	5	1151
Shale, green-gray, hard, calcareous	6	1157
Sample missing	6	1163
Shale, dark gray, slightly calcareous	5	1168
Shale, medium light, green-gray, hard, slightly calcareous	6	1174
Shale, medium, light green-gray, hard, calcareous	6	1180
Shale, same as above	5	1185
Shale, light green-gray, hard, slightly calcareous	5	1190
Shale, medium dark brown-gray, slightly calcareous	5	1195
Shale, gray, hard, calcareous	5	1200
Missing	6	1206
Shale, gray, medium hard, slightly calcareous	7	1213
Shale, gray, medium hard, slightly calcareous	5	1217
Shale, gray, lighter than above, medium hard, calcareous	5	1222
Shale, same as above	6	1228
Shale, medium gray, hard, calcareous	6	1234
Shale, same as above, little pyrite	5	1239
Shale, same as above, and limestone, dense, white, to light gray, some pyrite	5	1244
Kimmswick-Plattin (Trenton)		
Limestone, white to light flesh colored, gray, dense to finely crystalline	5	1249
Limestone, same as above, with some shale fragments, probably from above	3	1252
Limestone, light gray to buff-white, fine to coarsely crystalline, some calcite and pyrite	2	1260
Limestone, white to light gray and buff, finely crystalline	6	1264
Limestone, light yellow-gray, dense to finely crystalline, some calcite	6	1270
Limestone, gray to light flesh colored, finely crystalline, some calcite	5	1275
Limestone, same as above	5	1280
Limestone, same as above	5	1285
Limestone, light gray to light buff, finely crystalline, some calcite	5	1290
Limestone, light gray to light flesh colored, finely crystalline	3	1293
Missing	45	1338
Limestone, light buff to white, finely crystalline, granular, at 1354	..	1354
Limestone and calcareous shale, 50 per cent each, limestone, white to flesh colored, and buff; calcareous shale, variegated, dark gray to brown	52	1390

[a] The thickness of the samples in this log are given exactly as they were furnished by the driller.

The Kimmswick or "Trenton" limestone is a pure, crystalline limestone in which no dolomitization seems to have taken place. Where more coarsely crystalline, however, there is some appreciable intercrystalline porosity. If the well is located on favorable structure, pay would be expected within the first 50 feet, but it is possible to find an accumulation in the "Trenton" anywhere until salt or sulphur water is struck.

NEIGHBORING STRUCTURAL POSSIBILITIES

In T. 13 N., R. 8 W. (see fig. 2), there is evidence of an irregularity of structure. In the absence of samples and based solely on interpretation of drillers' logs, the top of the Kinderhook shale in the McDivett No. 2 well in the SE. ¼ NW. ¼ SE. ¼ sec. 22, is believed to be at an elevation of 162 feet below sea level, compared with 350 feet below in the J. W. Tomb well in the SW. ¼ NE. ¼ sec. 2, and an estimated elevation of 315 feet below in the Doctor Hughes Procter well in the NW. ¼ NE. ¼ sec. 5. The apparent increase of 150 to 180 feet in structural elevation of the McDivett well above the Procter and Tomb wells shows a north dip, much steeper than the general east regional dip. A cross fold or wrinkle plunging to the east may be present, its axis running southwest through the southwest corner of T. 13 N., R. 8 W. Any local flattenings or slight reversals, if present, on this axis or its possible continuation towards the west through the S. ½ T. 13 N., R. 10 W. would have interesting possibilities for oil accumulation in the various horizons mentioned before.

It is also worthy of note that the Salem is missing in the McDivett No. 2, the Pennsylvanian shales and shaly sandstones having been deposited directly on the eroded surface of the Mississippian Warsaw shale and limy shale. However, a hundred feet or more of Salem was found in the Tomb and Procter wells farther down the structural slope where erosion has not been so effective. Where the Salem formation has been weathered to a feather edge, the upper limit of which could be traced by a line roughly following a certain contour around the structure, there will be a progressive overlapping of the Pennsylvanian strata over the Salem and the underlying Warsaw. Without the presence of a reversal of dip or a closed structure, this lensing of the Salem limestone might very well afford good opportunities for the accumulation of petroleum even on uniformly dipping slopes or on the flanks of structural folds.

CONCLUSIONS

Although drilling costs are not great, due to the shallowness of the pay horizon, the production at best is only light. In general, the extent of the production may be expected to cover an area of several square miles, but because of the variable character of the sand, the risk of obtaining dry holes must not be overlooked.

In judging the commercial advisability of further drilling to the shallow pay in this area, the operator could expect wells averaging as those already drilled on the more favorable territory. It should be remembered that some risk of a dry hole is always present and that the amount of production can not be expected to be more than light, but that where one well can not be pumped at a profit, a number of wells of equal size pumped from a common power source may ultimately be profitable. The life and economic limit of the well, depending on the price of crude oil, the present worth of the ultimate production, and the drilling cost, are all factors that will affect the determination of commercial success in drilling this shallow field.

More extensive shallow drilling, particularly if continued to a persistent horizon in the Mississippian, such as the top of the Keokuk limestone, may indicate a favorable place for another deep test to the "Trenton."

Exploration of the lower pay horizons is justified in such an area as this, where for a width of six miles the strata have only a net rise of 30 feet. It has possibilities as a terrace and better chances for production if any closure is present. Intelligent testing by means of shallow holes to the top or base of the Keokuk-Burlington might well be made to determine whether the highest part of the terrace in the Mississippian and underlying formations is directly under the "structural high" in the Pennsylvanian strata and the old Mississippian surface in secs. 8, 16, 20, 21, and 29, as outlined in figure 1, or whether the higher portion of the terrace in the Mississippian and lower strata may not be farther to the west.

STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE

STATE GEOLOGICAL SURVEY

FRANK W. DE WOLF, *Chief*

EXTRACT FROM BULLETIN NO. 44

OIL AND GAS DEVELOPMENT AND POSSIBILITIES IN PARTS OF EASTERN ILLINOIS

BY

L. A. MYLIUS

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FRANK W. DEWOLF, *Chief*

PREFACE

In order to distribute without delay the results of the work by Mr. Mylius extending over several years, this brief abstract is issued in advance of the main report. It contains the author's recommendations for further prospecting in a large area in and near the main eastern oil field, though the reasons for some of the conclusions are not set forth at this time. In view of Mr. Mylius' resignation from the Survey to enter consulting practice at an early date it is especially desirable that his recommendations as to favorable territory should first be made public.

The work on which this abstract is based required the services of many associates and assistants to whom full acknowledgment will be made in the main report. However, the principal associate, D. M. Collingwood, should perhaps be mentioned at this time.

F. W. De Wolf, *Chief.*

OIL AND GAS DEVELOPMENT AND POSSIBILITIES IN PARTS OF EASTERN ILLINOIS

By L. A. Mylius

OUTLINE

OUTLINE—Continued

ILLUSTRATIONS

TABLES

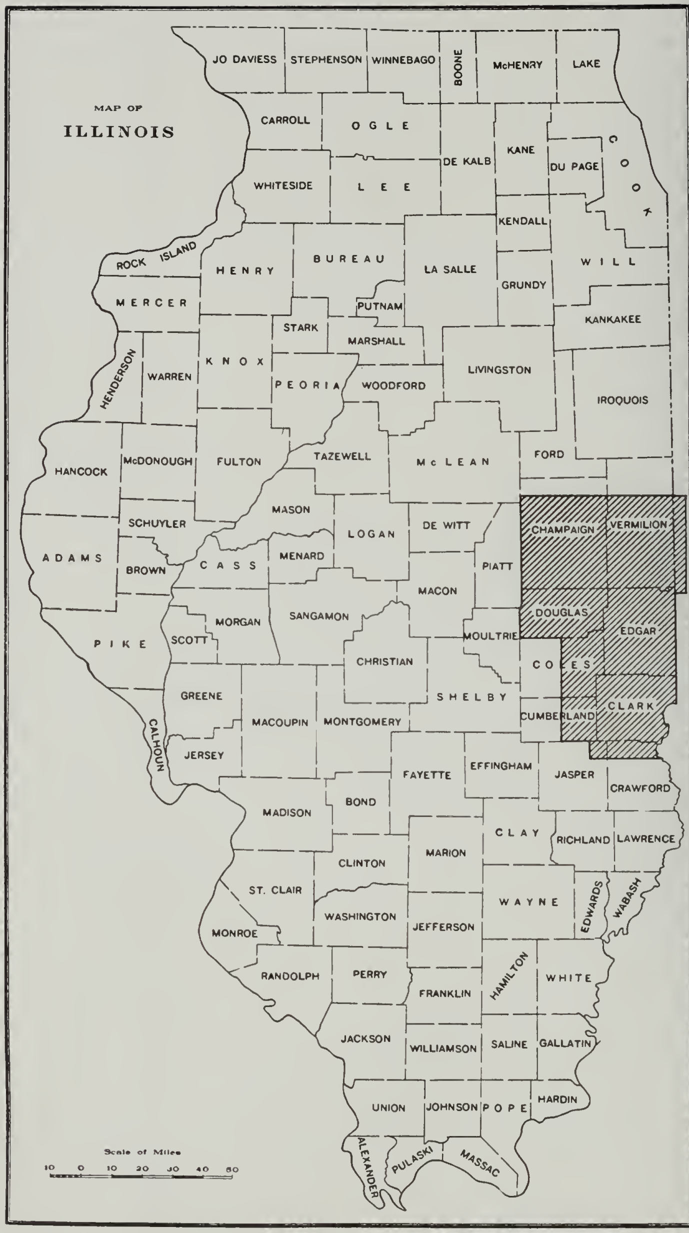

FIG. 1. Index map showing area described in detail by this report

INTRODUCTION

The scope of the present abstract of a much larger report is indicated by the table of contents, but it is desirable to mention other subject matter and illustrations which will appear in the full report and which are necessarily omitted from this abstract.

There will be large-scale maps of the producing area showing the usual features and including farm lines, wells, and contours on the various sands. Tables of well data for each pool, or for parts of pools that show distinctive sand features, will include logs of all producing wells and of many dry holes, together with details regarding sands, pays, shots, and similar items which will assist the operator to consider the deepening of present wells, and the application of new methods of recovery. Dry holes not included in the tables just mentioned are listed by section, township, and range as Table 5.

There will be ample discussions regarding practical methods of correlating the formations, the use of drill cuttings, water problems, drilling conditions, casing points, and similar features of operation.

Plate I is an important illustration of the present report, but unfortunately it is necessary to omit the detailed logs of the designated holes, most of which are based on study of samples. However the total depths of these holes is included. Only a few of the cross sections indicated on Plate I are presented here; all the others will appear in the complete bulletin.

Many ideas of theoretical nature but believed to have practical value are reserved for the later bulletin. Some relate to the control of sedimentation during Pennsylvanian time, and to the resulting sand distribution. The evidence will include maps and cross sections. Considerable attention will be devoted to the origin and accumulation of oil, based on abundant data which are believed to justify some departure from theories ordinarily held.

The omitted material, both practical and theoretical, has an important bearing on the consideration of future prospecting. On that account many readers may not fully understand or agree with the author's viewpoint. It is unfortunate that the reader can not have at once a presentation of all the evidence which is believed to justify the writer's conclusions.

LOCATION AND SUBDIVISIONS OF THE AREA

The area being treated in particular includes all of Champaign and Vermilion counties south of T. 21 N.; most of Douglas, Edgar, and Clark counties; the eastern half of Coles County; the eastern part of Cumberland County; T. 8 N., Rs. 13 and 14 W., Crawford County; and the northeastern corner of Jasper County (fig. 1).

The irregularity and the variations in the occurrence of the different geological systems make it advisable to divide the area into sub-areas for the discussion of certain necessary details. These sub-areas are purely arbitrary but in each, somewhat similar conditions seem to prevail, though the evidence may be partly controlled by the limited number of tests made (Pl. I).

DRAINAGE AND SURFACE RELIEF

The area is drained by Wabash River to the east and the Embarrass to the west. The divide trends approximately north and south through R. 13 W. from Crawford to Vermilion County, but from there trends northwest toward Champaign, in which vicinity are the head waters of the Embarrass. The tributaries of the Wabash, which in general flow in a southeastward direction, are much more mature, resulting in greater surface relief than those of the Embarrass, which flow southwest.

On the whole the area is rolling prairie with a gradual decrease in elevation from north to south of from 750 to 550 feet. The tributaries of the two main streams have resulted in dissected country in parts of the area, especially along the eastern side and in the southern part of Clark and in Crawford County where the local relief rarely exceeds 100 feet, whereas the maximum variation in elevation over the whole area is about 300 feet, from 750 feet near Champaign to 450 feet in northeastern Crawford County. The glacial moraines that cross this area from east to west are in part at least the cause of the increased elevation in the northern part of the area and of the scarcity of rock outcrops over the whole area.

EXTENT OF THE PRODUCING AREA

In the entire area commercial production is now limited to parts of T. 11 N., Rs. 10 and 11 E., Coles County; T. 10 N., Rs. 10 and 11 E., Cumberland County; T. 12 N., R. 14 W., T. 11 N., R. 14 W., T. 10 N., Rs. 13 and 14 W., T. 9 N., R. 14 W., Clark County; T. 8 N., R. 14 W., Jasper County; and T. 8 N., Rs. 13 and 14 W., Crawford County. Excluding sub-area Q, which is not studied in detail, the total area is approximately 90 square miles, in which about 38 square miles actually have produced oil or gas. In T. 14 N., R. 14 W., gas and some light oil wells have been found, but as yet no production of importance has been developed. The pools in the described area are known as the Parker pool, Siggins pool, York pool, Casey Township pools, Martinsville pool, Johnson and Orange pools, and Bellair pool (Pl. I).

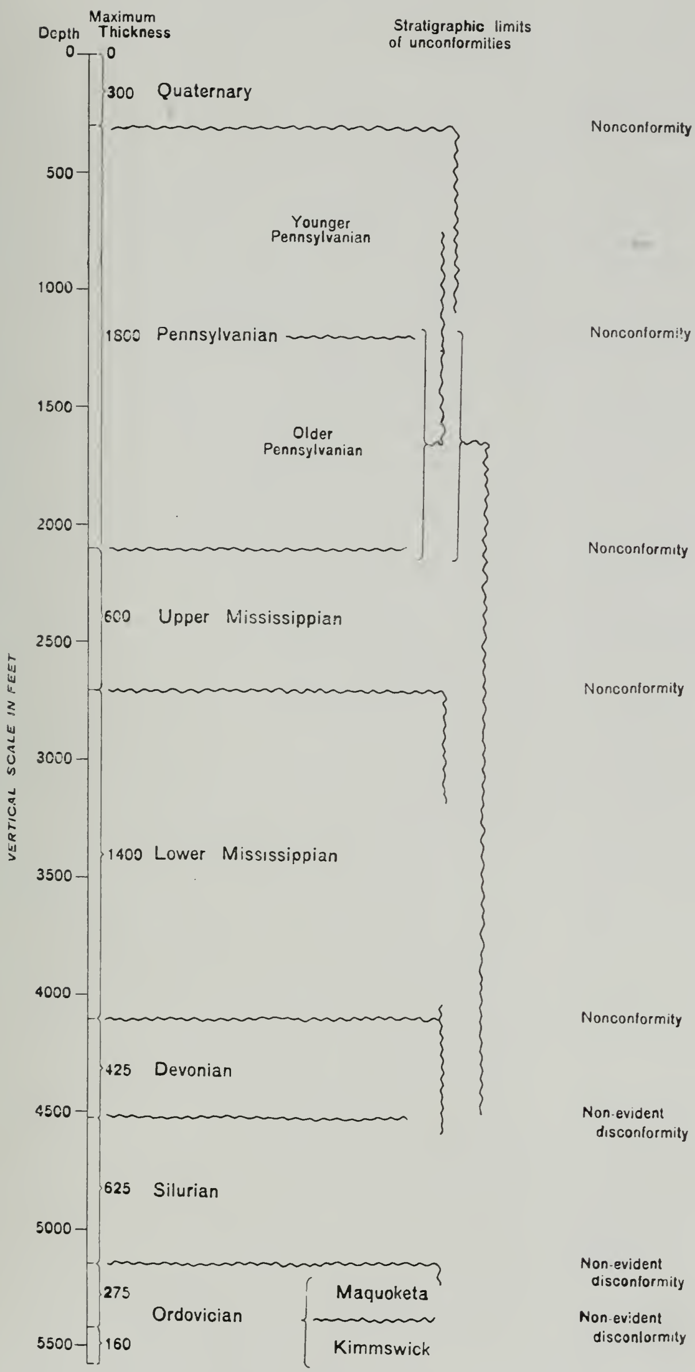

FIG. 2. Geologic table showing known unconformities and their stratigraphic extent

STRATIGRAPHIC RELATIONS

The general nature of the beds that will be discussed in great detail in the completed report is given on Plate II. Figure 2 shows the inter-relations of the different geological systems and the stratigraphic extent of the unconformities. The terminology by which the unconformities are designated is after Pirsson and Schuchert.[1] The maximum thicknesses of basal beds not deposited prior to overlapping, is shown approximately for the Kimmswick (zero), Lower Mississippian (about 75 feet) and Pennsylvanian (about 1500 feet), but for the Silurian, Devonian and Upper Mississippian, the amounts although apparently slight cannot be isolated. The unconformity within the Pennsylvanian is only approximate as to position, as the complex conditions resulting from the two unconformities that influence Pennsylvanian sedimentation are not thoroughly understood. Varying thicknesses of Pennsylvanian are found capping beds down to the Devonian as indicated by the vertical line. Also varying thicknesses of Lower Mississippian and Devonian are found underlying Upper Mississippian and Lower Mississippian beds, respectively, as shown by the vertical extent of those unconformities. The regional result of all these unconformities is shown in part by Table 1 containing a summary of the thicknesses of the formations in the sub-areas, and will be discussed fully in the completed report.

In this table the minimum totals may be too small and the maximum too large, chiefly on account of the variable thickness of Quaternary which has been contrasted to consider a minimum and maximum figure. Also the approximate elevations given must not be considered exact. Another small error may be due to the fact that the systems do not always vary similarly in their thicknesses. For instance, the Maquoketa thickens generally to the south, whereas the Mississippian in some areas will thicken more to the east or west. On that account the location of an individual maximum depth does not represent an exact combined maximum thickness.

SANDS

Producing Sands in the Area

The producing sands of this area vary from 300 to 2300 feet in depth, and in geological age from Pennsylvanian to Ordovician, as shown in Table 2. The following description begins at the north and proceeds southward.

In the Parker Township pool the main producing zone is in the Lower Mississippian limestone of Spergen age. Several pays are found in the

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[1] Pirsson, Louis V., and Schuchert, Charles, A text-book of geology, p. 292, 1915.

TABLE 1.—*Summary of the thicknesses of the formations in the sub areas indicated on Plate 1*

Sub-area		Part of sub-area	Quaternary	Pennsyl-vanian	Upper Mis-sissippian	Lower Mis-sissippian	Devonian and Silurian	Ordovician (Maquoketa)	Approximate depth to top of Trenton	Approximate elev. of top of Trenton	Remarks
			Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	
A	Min.	East edge	50	100	0	300	700	190	1340	—650	Devonian and lower formations thicken southward; remaining formations thicken chiefly westward.
	Max.	Southwest	150	1100	400	1050	800	225	3725	—2925	
B	Min.	Central	150	0	0	0	725	190	1065	—335	Devonian and lower formations thicken south; rest thicken toward edges of sub-area.
	Max.	South and West edges	300	100	0	300	780	225	1705	—725	
C	Min.	Western edge	100	75	0	175	700	225	1275	—525	Devonian and older formations thicken south; all others thicken toward central part and to the south.
	Max.	South central	150?	350	0	700	825	240	2265	—1525	
D	Min.	North central	100	50	0	350	700	225	1425	—725	Pennsylvanian strata thicken toward edges; Mississippian toward east and south; Devonian and older formations toward south.
	Max.	South and around edges except North	200?	250	0	700	825	250	2225	—1475	
E	Min.	Northeast and Northwest	50	250	0	450	675	225	1650	—1050	Devonian and older strata as above. Above Devonion, the formations thicken southward through synclinal basin; then thin eastward.
	Max.	South central	300?	800	50?	1100	825	250	3325	—2725	

TABLE 1.—*Summary of the thicknesses of the formations in the sub-areas indicated on Plate I—Concluded*

Sub-area		Part of sub-area	Quaternary	Pennsyl-vanian	Upper Mis-sissippian	Lower Mis-sissippian	Devonian and Silurian	Ordovician (Maquoketa)	Approximate depth to top of Trenton	Approximate elev. of top of Trenton	Remarks
			Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	
F	Min.	Northeast	50	200	0	600	650	225	1725	—1125	Devonian and older strata as above. Above Devonian the formations thin to east and thicken to south.
	Max.	Southwest	200?	550	0?	1000	800	240	2790	—2100	
G	Min.	Northeast corner	100	100	0	600	775	225	—1800	—1100	Devonian and older strata as above. The formations above Devonian thicken sharply at first, then gradually to west; thickest south and west.
	Max.	Southwest	200	1700	700	1500	1100	275	5475	—4775	
H	Min.	North end	50	100	0	300	800	225	1475	—825	All formations thicken southward. Data very general on this sub-area.
	Max.	South end	200?	1000?	200?	1250	875	250	3775	3075	
I	Min.	Northwest corner	50	100	0	400	800	240	1590	—950	All formations thicken to the south. All above Devonian show thickening toward central part. Slight variation of west edge would cause large amout of thickening in upper systems.
	Max.	Southeast and south central	200?	500	0	1100	850	250	2900	—2100	
J	Min.	North central	50	200	0	500	825	250	1825	—1150	Devonian and older strata thicken to the south. Above Devonian they thicken toward edges and to the south.
	Max.	Around edges and South	150?	350	0	900	840	250	2490	—1800	

K	Min.	Northwest corner	50	250	0	650	825	250	2025	1425	All formations thicken southward. Above the Devonian, formations thicken through central synclinal basin and then thin farther east.
	Max.	South central	200?	900	400	1200	900	250	3850	—3150	
L	Min.	Northwest	50	450	0	700?	825	250	2275	—1625	All formations thicken south. Those above Devonian thicken irregularly due to structure.
	Max.	Southwest	150?	800	150	1250	900	260	3510	—2850	
M	Min.	North central	50	250	0	880	835	250	2265	—1630	All formations thicken to south. Above Devonian, all thicken toward edges.
	Max.	Southeast and West edge	150?	500	0	1150	900	260	2910	—2300	
N	Min.	Northwest corner	50	450	0	1000	835	250	2585	—2000	All formations thicken to south. Above Devonian, all thicken both east and west.
	Max.	Southeast	200?	1200	600	1400	1100	275	4775	—4325	
O	Min.	North end	50	650	50	1100	900	260	3010	—2325	All formations thicken to south. Above Devonian, all thicken in general to west.
	Max.	Places along West edge	200?	1250	400?	1400	975	275	4500	—3700	
P	Min.	North end	50	400	0	950	900	260	2560	—1900	All formations thicken to south. Above Devonian, all thicken toward edges.
	Max.	South end	150?	850	400	1350	975	275	4000	—3400	
Q	Min.	North	100	800	400	1350	975	275	3900	—3300	All formations thicken to south. Above Devonian, all thicken to east and west.

upper 200 feet of this limestone from 300 to 500 feet below the surface. A gas sand of Pennsylvanian age about 60 feet above the Mississippian lime has given some production. The Trenton (Kimmswick of the Ordovician) limestone at a depth of approximately 2300 feet, has recently been demonstrated commercially productive in its upper 160 feet. In the Martinsville pool the main production comes from the upper part of the Lower Mississippian limestone, probably of St. Louis age, at a depth of approximately 500 feet, but the Carper sand of the basal Mississippian is now being developed. The Siggins pool, York pool, Casey Township pools, and Johnson Township pools produce chiefly from Pennsylvanian sands at depths of from 300 to 700 feet from the surface. The Bellair pool has production from Pennsylvanian sands at depths of from 500 to 700 feet, and from Chester sands at depths of from 800 to 950 feet. Between the Bellair pool and the main Crawford County pools, production comes from Pennsylvanian sands at 900 to 1,000 feet.

Producing Sands of Lawrence and Crawford Counties and their Statigraphic Relations to Sands in this Area

The oil sands in Lawrence and Crawford counties have been described by R. S. Blatchley[2] and the Allendale[3] and Flat Rock[4] oil fields by J. L. Rich.

The longitudinal section from Lawrence to Coles counties (Pl. II), approximately following the main anticlinal crest, shows the general behavior of the different geological formations along the strike. The depths to the different pays and the thicknesses of the different formations are generalized and must not be considered exactly to scale except at the numbered localities. The flattening suggested in places is not intended to be indicative of localized structure.

Tables 1 and 2 and the longitudinal section (Pl. II) indicate that some lower beds of the rock section that are important producers in Lawrence and Crawford counties do not exist to any important degree in the area being specially considered in this report. But the deeper beds have been brought up within commercial reach of the drill and reservoirs have been formed under favorable structural conditions. Some of these lower producing sands have been commercially developed and still others offer production in different parts of the area.

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[2] Blatchley, R. S., Oil fields of Crawford and Lawrence counties: Ill. Geol. Survey Bull. 22, 1913.

[3] Rich, John L., The Allendale oil field: Ill. Geol. Survey Bull. 31, p. 57, 1915.

[4] Rich, John L., Oil and gas in the Birds Quadrangle: Ill. Geol. Survey Bull. 33, p. 124, 1916.

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[2] Blatchley, R. S., Oil fields
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[3] Rich, John L., The Allend
[4] Rich, John L., Oil and ga
p. 124, 1916.

The deepest producing sand in Lawrence County is the McClosky of the oolitic Ste. Genevieve limestone horizon of the Lower Mississippian. The Ste. Genevieve is about 150 feet thick in Lawrence County and occurs in decreasing thicknesses northward along the higher parts of the main structure as far as Johnson Township, Clark County. The most noteworthy oil occurrence is in the very porous oolitic beds from 1 to about 8 feet thick, occurring at several horizons in the upper 90 feet of the Ste. Genevieve. The wells from these thin sands were relatively large, some having produced over 2,000 barrels per day. These very porous dolomitized, siliceous oolitic beds give a natural production and are not shot. In general, the porosity is believed to have resulted from the weathering of the oolitic beds at or near a former erosion surface. Where the Ste. Genevieve is less porous the wells, varying in size with other conditions of structure and porosity, obtain production by shooting a greater thickness of the oolitic limestone. The Ste. Genevieve has not been commercially developed over the area of the main Crawford County field although it has provided unimportant amounts of oil in the Bellair pool to the north.

The main production of Lawrence County comes from the Chester or Upper Mississippian group, which varies in thickness from 500 to 600 feet in the producing territory. Oil is obtained from at least eight specific places in the section. The producing oil sands have been grouped by three names: the Tracey, corresponding to the lower; the Kirkwood, to the middle; and the Buchanan, to the upper. In no single locality do all of these groups exist under best conditions, but certain areas have more pays in the Chester than do others.

With the exception of a few very small areas, the main Crawford County pool has not been drilled to these Chester sands (Pl. I). But in the Bellair pool, Licking Township, where the Chester has thinned to about 250 feet, it produces from at least five pays, grouped as the 800-and 900-foot sands; and in Clark County, occasional pays occur in remnants of the Chester about 100 to 150 feet thick.

The pays in the Chester are in sandstones, sandy limestones, and porous oolitic or impure limestones varying in thickness from 5 to 30 feet. The lateral extent of an individual zone of sand is considerable in parts of Lawrence County, and the change of an individual bed from sand to sandy lime is not so marked as in the north at Bellair. However, considering the Chester in its general distribution there is marked lateral variation in the nature of the rocks. A zone of porous beds associated with shales may occur at any place in the Chester section but the lateral extent of an individual porous oil-producing bed is limited.

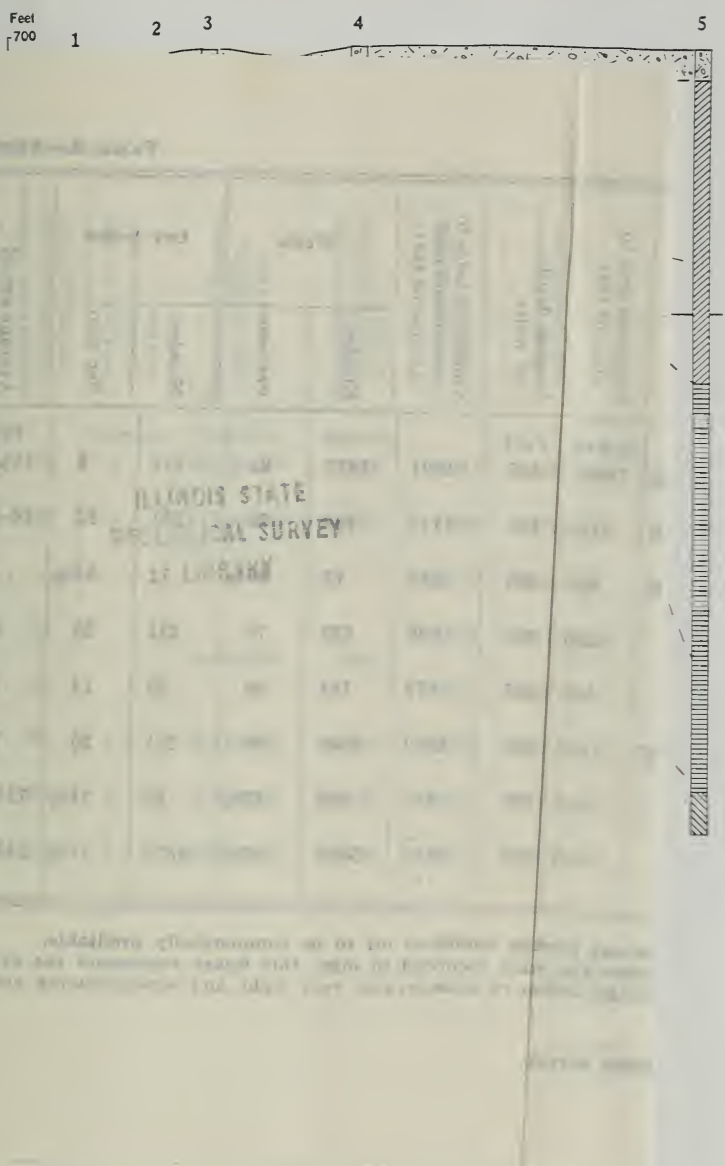
The basal part of the Pennsylvanian gives considerable production in Lawrence County, and the chief production in Crawford County. In both

these counties the Pennsylvanian production is obtained from a basal zone approximately 250 feet thick with pays at various depths in the zone. These pays appear in the same approximate stratigraphic position, and consistent shale beds separate the upper and more prolific zone from the lower. These productive Pennsylvanian sands are called Bridgeport, and rarely Little Buchanan or Ridgely in Lawrence County, and in Crawford County are usually termed the Robinson sand lenses. Some gas and oil production is found locally above the 250-foot zone, but in general is unimportant. The basal Pennsylvanian is the main oil-producing zone as far north as to include the Siggins pool in Cumberland County. The producing basal part in Lawrence and Crawford counties is probably of Pottsville and lower Carbondale age, but in Clark and Cumberland counties the basal zone is younger, being chiefly upper Carbondale and McLeansboro. Individual Pennsylvanian pay sands in Lawrence and Crawford counties vary in thickness from about 10 to 60 feet, or more in exceptional cases. The thickness of actual pays, although sometimes recorded in logs as much as 60 feet, is less, as only a part of such thick sands contributes oil in important amounts. The sands vary from medium-coarse, porous sandstones to fine-grained sand and sandy shale. Wide ranges in porosity of the sand are common.

GENERAL STRUCTURE

Description of the Bellair-Champaign Uplift

A part of this area is a structural uplift, the western edge of which is in line with the La Salle anticline; but although that anticline is commonly pictured as fairly definite at La Salle to the north and in a part of Lawrence County to the south, it is not a definite and continuous individual fold, at least in the area under discussion. The uplift is structurally elevated above the Illinois basin on the west and above a pronounced north-south syncline known as the Marshall Sidell syncline, on the east, but this uplift instead of being flat or having a definite anticlinal crest has a series of local domes and shallow basins and as a whole seems to widen in an east and west direction as it extends from Bellair northward. The writer's interpretation is partially suggested by Plate I and by several cross sections (Pls. III, IV, V, VI and VII), which emphasize the raised position of a large area but indicate the presence of a depressed central tract flanked by two belts or zones in each of which domes and intervening basins seem to be somewhat aligned. Thus a cross section (Pl. III) indicates a marked anticline on the west and a very slight reversal of dip on the eastern belt separated by a syncline, while Plate IV shows the eastern anticline with marked relief because the section is taken across a minor fold. Plate VI shows two marked anticlines but an east-west cross section a few miles



5. Detailed log No. 51

Ordovician

Structural section J-K of the Oakland dome. Log No. 1 is adjusted approximately to the line of section. The possible continuation of cross fold No. 8 may modify the eastern dips shown here.

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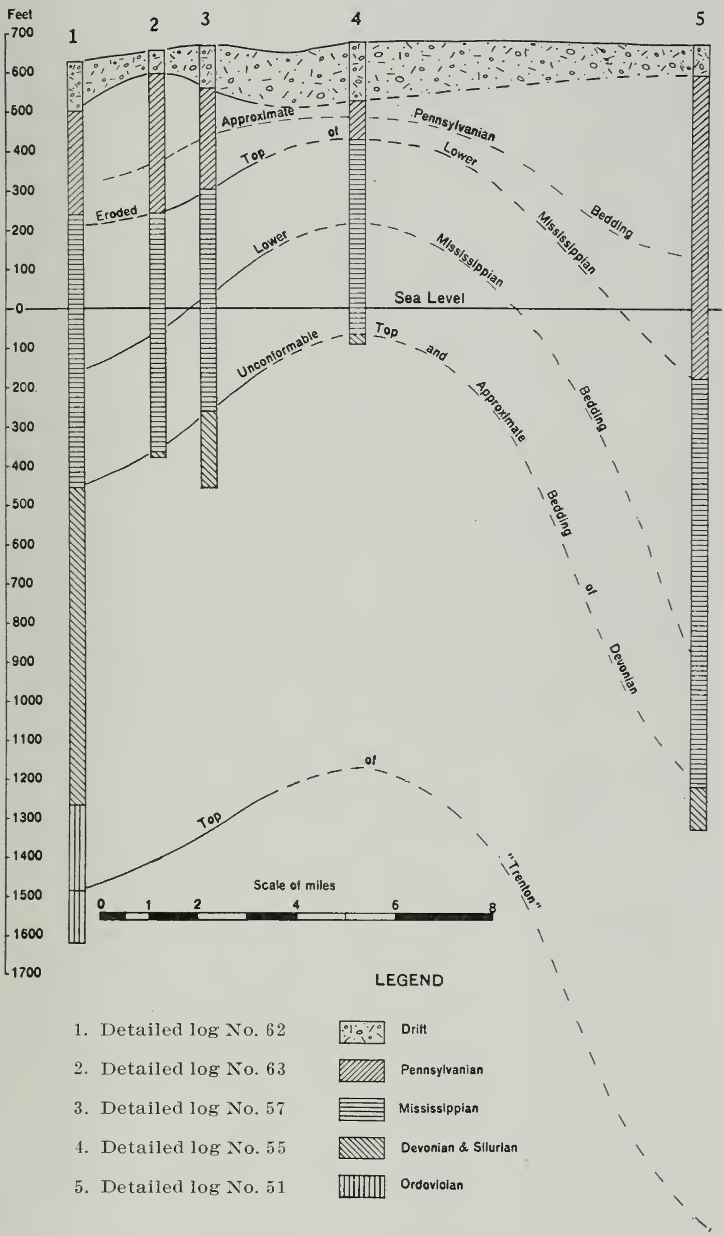
ILLINOIS STATE GEOLOGICAL SURVEY BULLETIN NO. 44, PL. IV



Structural section J-K of the Oakland dome. Log No. 1 is adjusted approximately to the line of section. The possible continuation of cross fold No. 8 may modify the eastern dips shown here.

north would show a reduction in the relief and an eastward migration of the anticlinal dips with only slight elevations there above the mean structural level of the central area.

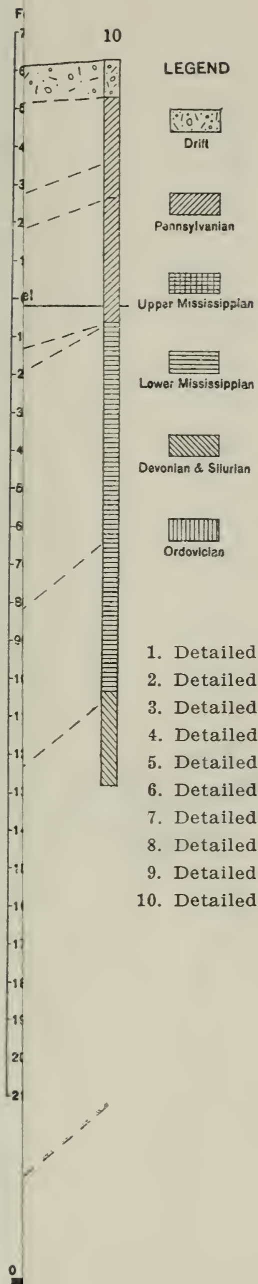
It is necessary to emphasize the irregularity of this uplifted zone and the consequent patchy distribution of oil pools so far as their locations are determined by structure. For this reason in part the writer prefers not to designate the uplift as the La Salle anticline but as the Bellair-Champaign uplift. Indeed it seems possible that while the western belt of aligned domes represents the La Salle anticlinal belt, and will be so designated, the eastern known as the Oakland anticlinal belt may represent a distinctive fold which extends from the north into this area and merges with the La Salle. In neither case is there a continuous anticlinal fold, the synclines of cross folds rendering either or both belts of the uplift monoclinal at places, but there is evidence that domes occur in these belts rather than outside of them and it seems probable that more will be revealed by future drilling within and near these belts. The series of diagonal or so-called cross folds which are related to the occurrence of these domes are discussed on page 32.

The location and extent of each of the larger features may be described briefly. The western edge of the Bellair-Champaign uplift, which constitutes the eastern edge of the central Illinois coal basin, extends across this area from the northwest corner of Crawford County T. 8 N., R. 14 W., to T. 20 N., R. 6 E., passing through T. 10 N., R. 10 E., and T. 15 N., R. 8 E. East of the uplift, the Marshall-Sidell syncline is found between it and the area bordering the Illinois-Indiana state line. The western edge of this decided syncline, which is the eastern edge of the uplift, runs irregularly somewhat west of north from T. 8 N., R. 13 W., to T. 11 N., R. 14 W., and thence approximately north to T. 18 N., R. 14 W. Over the whole area both in the synclines and on the uplift there is a regional pitch of the strata to the south. Thus the lower beds of the rock section were brought closer and closer to the surface to the north (Pl. II). However, this pitch is markedly modified by local structures. The structural relief of the uplift is more accentuated in the strata older than Pennsylvanian than in the Pennsylvanian, and the pre-Pennsylvanian strata pitch from the north end of the area to the south end of Lawrence County about the same amount as they dip from the north end into the closely adjoining basin on the west (Pls. II, III and VI).

SUMMARIZED DATA OF THE POOLS

Table 3 is compiled from the 6000 well and dry hole logs and other detailed information that will be presented in full in the complete report.

Table 4 presents the curb elevations and total depths of holes located on Plate I. Detailed logs of these will appear in the later report.



1. Detailed log No. 109
2. Detailed log No. 108
3. Detailed log No. 97
4. Detailed log No. 107J
5. Detailed log No. 107C
6. Detailed log No. 107Q
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10. Detailed log No. 98

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TABLE 4.—*Total depths and elevations of all holes‡ located on Plate I*

Well No.	Total depth	Curb elevation	Well No.	Total depth	Curb elevation
	Feet	*Feet*		*Feet*	*Feet*
Champaign County			Clark County—Concluded		
1.......	1679	692	116.......	704	613
2.......	1085	710	117.......	3017	515
16.......	502	750	118.......	....	....
17.......	1838	740 (est.)	*119 A....	2830	568
*21 A....	1189	735 (est.)	B....	521	597
B....	2000	730 (est.)	120.......	2875	553
22.......	662	675 (est.)	121.......	2260	602
34.......	600	675 (est.)	*122 A....	642	595
35.......	1750	720	B....	650	579
36.......	848	685 (est.)	C....	645	564
			123.......	2642	640
Clark County			Coles County		
95.......	1075	710 (est.)	63.......	1032	654
96.......	1197	679	64.......	1123	657
97.......	2680	651	*65 A....	600	626
100.......	2275	550 (est.)	B....	300	641
101.......	1015	600 (est.)	C....	313	659
102.......	1040	610 (est.)	D....	560	665
103.......	2254	603	E....	2226	665 (est.)
104.......	740	600	66.......	2150	659
105.......	724	625 (est.)	67.......	951	661
106.......	1301	603	*68 A....	885	661
*107 A....	2622	672	B....	900	660
B....	2476	660 (est.)	70.......	505	659
C....	2479	650 (est.)	85.......	2734	665
D....	2445	655	86.......	789	661
E....	2440	658	91.......	1500	700 (est.)
F....	2427	662	92.......	2500	704
G....	2471	666	*99 A....	840	725 (est.)
H....	2445	660	B....	1327	725 (est.)
I....	2412	659	108.......	2503	642
J....	2452	660	109.......	740	700 (est.)
K....	2443	657			
L....	2435	657	Crawford County		
M....	2457	655 (est.)			
N....	525	635	*131 A....	876	523
O....	2540	653	B....	918	514
P....	2918	670	C....	912	549
Q....	2508	657	D....	862	542
*113 A....	548	593	132.......	1250	526
B....	580	558	*140 A....	1065	490
114.......	560	617	B....	966	500 (est.)
115.......	502	580	141.......	4620	525 (est.)

TABLE 4.—*Total depths and elevations of all holes‡ located on Plate I*—Concluded

Well No.	Total depth	Curb elevation
	Feet	*Feet*
Cumberland County		
111	2300±	650
112	1913	623
124	1050	623
Douglas County		
37	810	645 (est.)
38	1042	639
39	830	642
40	680	669
*41 A	780	654
*41 B	300±	660
43	1697	674
44	576	637
45	819	672
46	864	643
47	928	644
48	1200	646
56	896	638
57	1120	667
58	523	674
59	607	679
60	930	643
61	1270	664
62	2237	626
Edgar County		
49	815	714
50	1206	625 (est.)
51	2000	673
52	921	661
53	895	658
54	896	651
55	769	676
71	406	657
*72	240	663
*73 A	270	666
*73 B	715	666
*73 C	248	665
*73 D	291	667
74	2075±	681
*81 A	558	636
*81 B	611	683
82	504	684
Edgar County—*Concluded*		
83	403	675
*84	248 (Max.)	669
87	637	735
93	2750	727
94	522	757
Jasper County		
143†	1807	590
Lawrence County		
142	3515	485 (est.)
Piatt County		
18	1070	707 (est.)
Vermilion County, Illinois		
3	1000	584
4	915±	620 (est.)
*13 A	2008	615
*13 B	1149	650
14	499	645
15	780	660 (est.)
23	1252	678
24	700	689
25	485	625
29	1325	....
31	1537	663 (est.)
32	1303	650 (est.)
33	920	698
Vermilion County, Indiana		
11	208	479
12	281	547
27	398	596
26	1026	611
28	2442	560
Vigo County, Indiana		
98	1912	650 (est.)

‡ Detailed logs of these holes will be published in the complete report.
* Number refers to a group of wells.
† Well located outside area included in Plate I.

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A list of outlying dry holes not included in other tables, and of which only partial logs and information were obtainable is given in Table 5.

TABLE 5.—*Data on outlying tests for which detailed logs are not available*

The complete report will contain a discussion of the coal correlations of the Danville area. The coal previously considered about equivalent to No. 6 of southern Illinois is believed by the writer to be about 250 feet higher in the Pennsylvanian section and any reference to the logs of Illinois Coal Mining Investigations Bulletin 14 should take this into consideration.

T. 20 N.

Ranges 14, 13, 12, 11 West: See Illinois Coal Mining Investigations Bulletin 14. O. M. Van Allen tests shown in sec. 6, T. 20 N., R. 12 W., should be in sec. 6, T. 19 N., R. 12 W.

T. 19 N.

Ranges 14, 13, 12, 11 West: See Illinois Coal Mining Investigations Bulletin 14. Note O. M. Van Allen tests as above sec. 6, T. 19 N., R. 12 W.

T. 18 N.

Ranges 14, 13, 12, 11 West: See Illinois Coal Mining Investigations Bulletin 14.

T. 17 N.

Range 10 East, Raymond Township: Several shallow holes; none over 400 feet in depth.

Range 11 East, Ayers Township: One hole about 1,000 feet deep in vicinity of Broadlands. Exact location not known; may not be in Ayers Township.

Ranges 14, 13, 12, 11 West: See Illinois Coal Mining Investigations Bulletin 14.

T. 16 N.

Range 8 East: In and around Tuscola about six holes not listed; one west of Illinois Central station, two east of Illinois Central station, two at ice plant, and one south of Chicago and Eastern Illinois station; deepest well 850 feet; characteristic logs given with detailed logs. Water usually found in Devonian contains approximately 500 parts mineral matter per million.

Range 9 East: Wainscott No. 1, located between Villa Grove and Fairland, but exact location not known. Not over 900 feet deep. Richman well in sec 34 (?) west of Camargo not over 700 feet deep.

Range 10 East: Helm well in sec. 30, 352 feet deep, 7 feet coal reported at about 320. One hole in sec. 29, not so deep as above.

Range 11 East:

Section	Farm	Total depth *Feet*	Remarks
25, SE	Wagner	900	Dry.
33 NE	Moore	802	Dry.

Ranges 14, 13, 12, 11 West: See Illinois Coal Mining Investigations Bulletin 14.

T. 15 N.

Range 8 East: Several shallow water wells in eastern part of township, deepest 300 feet, reach Devonian at about 50 feet in sec. 1.

Range 9 East: Several shallow water wells in western part of township, reach Devonian at about 200 feet in secs. 5 and 6.

Range 10 East:

Section	Farm	Total depth *Feet*	Remarks
25, SW	Gwinn	1100	Reached Devonian lime at about 1050 feet. Shows of oil in upper part of hole.

Range 14 West:

Section	Farm	Total depth *Feet*	Remarks
1, NE. NE	Morrow? (Meyers?)	900	Drilled by C. Carns et al. Top of Devonian 885 feet. Show of oil. Hole full of water.

Ranges 14, 13, 12, 11, West: See Illinois Geological Survey Mining Investigations Bulletin 14. Coal tests secs. 29, 30, Edgar Township (T. 15 N., R. 11 W.).

T. 14 N., R. 10 E.

Section	Farm	Total depth *Feet*	Remarks
13, NE. NE	S. Swinford	542	Slate and coal at 360 feet; reported 6 feet of coal; limestone roof; 15 feet good sand at 492 feet; salt water at 542 feet.
26, NW	S. Pearson	900?	5 feet sand at depth of 400 feet.
33, NE	J. T. Taylor	Not over 1000	Struck some gas.
8, NE. SE	Z. Green	987	Coal at 270 feet; 4-feet; salt water at 350 feet; gas at 720 feet.

T. 14 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
13, SE. NE	J. Barton	400	Flowed salt water.
14, SE. SE	W. Borton		Show of oil, at a depth not more than 400 feet.
16, SW	Swinford	400	4 feet of sand at 98 feet; 21 feet of sand at about 300 feet; salt water about 350 feet; went through 2 coals, depth not given.
16 SE. SE	I. Mapes	About 350	Show of oil in sand 290–310 feet; some gas at 350 feet.
21, SW	B. Sherman	350?	Show of oil.
22, NW. SE	A. S. Craig		Dry hole; not over 500 feet deep.

24, NE.? NW	E. Blair	Not over 400	Two holes before latest drilling. One connected with hand pump still shows oil.
25, NW	James Buckler	One about 500, rest not over 400.	About 7 wells; 1 in NE. corner of farm, dry; 3 straight east of house; about 3 wells south. Oil about 250 feet. Wells pumped for some weeks.
26, NE	James Buckler	Not over 400	
27, SW. NE	C. A. Ogden	300	Dry.
28, NE	W. B. Buckler	400?	No log.
32, NW. SW	Elby Ashmore	789	Sand 300–330 feet; full of water at 450 feet; oil sand and show at 520 feet; small show; at 680 feet bluish sand; and at 789 feet heavy salt water.
33, SE	C. C. Childers	1100?	Dry; may have been 1100 feet deep.
34, SW	Craig No. 1	400	Gas and little oil in sand at 140 feet.
	No. 2	300	Gas in sand 140–155 feet; good show of oil in sand 175–200 feet.
34, NE. SE. NE	Albert Coffee	Not over 400	Sand with show of oil at 150–200 feet; shot; sand with good show at 350 feet; not shot.
34, SE. SE	J. H. Handley Nos. 1, 2, 3, 4, 5, 6.	None over 250	Wells drilled about 1908; some still pump a little oil; same sand as in other Handley wells, which are listed with detailed logs.
35, SE. SW	J. F. W	Not over 600	Gas well; no record.
35, NE. SE	W. Geyer		No record; probably very shallow.
35, SE. NW	E. B. Hickey ? No. 1	225	Fair show at about 200 feet.
	No. 2	400	Salt water at about 200 feet.
35, NE. NW	V. McAdams	300	Sand top 140 feet; good show at 200 feet; pumped for weeks; made 5 barrels at first.
35, NE	J. E. Bradley (Now Black)	210	Sand with oil; shot 193 to 205 feet.

T. 14 N., R. 13 W.

Section	Farm	Total depth *Feet*	Remarks
19, NE. NW	J. H. Stephenson	Not over 400	Showed coal.
31, NW. NE	J. Honnold (Now Collier)	400	Sand 350–375 feet with gas; show of oil in bottom. Most shows in this area were in limy sand.

31, SW. SW	J. P. Parisha (Now Collier)	Not over 400	Good show at 300 feet.

T. 13 N., R. 10 E.

Section	Farm	Total depth *Feet*	Remarks
29, NE	Olmstead		No record available. Drilled by Bendeman and Trees.
35, SE	Dougherty heirs		?
34, SW. SW	S. C. Courtney	535	Sand with show at 380–460 feet.

T. 13 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
1, NW	J. L. Honnold	None over 500	About 9 holes; most were light oil wells. Could not shut off upper water, especially after shot; no suitable casing seat.
2, SW. NE	J. L. Honnold	625	Gas well.
2, NW. NW	S. F. Honnold	Not over 500	Two dry holes; small show in shale at 400 feet; no good sand; water at 75 to 82 feet.
3, NE. NE	S. F. Honnold	215	Two holes with same sand as producing wells on Handley; pumped for some weeks.
12, NW. NE. NE.	Wm. Juntgen	Not over 400	Show of oil; was shot.
33, SE	G. Atterbaum	720	Dry hole; sands 252–272, 322–326, 545–720 feet.
33, SW	W. B. Zimmerman	Not over 750	No Mississippian lime until 540 feet, but Mississippian top probably higher.

T. 13 N., R. 13 W.

Sec. 32, SE., A. V. Smith; sec. 33, SE., E. B. Smith; sec. 34 NW., Fred Smith, reported to have given gas. None over 600 feet deep.

T. 12 N., R. 9 E.

Section	Farm	Total depth *Feet*	Remarks
13, SW. SW			Dry; shallow.
13, SE. NW	A. Crews	596	Dry.

T. 12 N., R. 10 E.

Section	Farm	Total depth *Feet*	Remarks
1, SE	Eli Dudley		Shallow hole; show of oil.
1, NW	Hawkins		Shallow?

12, SE	J. Dudley	Not over 400	
13, NW	J. I. Bull		No record, shallow.
14, SE	B. F. Cutler		No record, shallow.
15, NW	T. E. Walton	895	Dry.
23, SW	B. Drew	?	Dry; shallow.
29, NE. SE	Rennels	810	Show; dry.
29, SW. SW	Farr	575	Show; dry.
29, SW. SW	Farr	825	Show; dry.
31, NE	?	?	Shallow; dry.

T. 12 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
6, SE. SE	C. Reed	675	Sand 440–456 feet, show; lime 456–525 feet.
7, NW. SW	T. A. Wallon	900?	No record.
8, SW	V. Green	800	No record.
9, NW	C. A. Hite		Mississippian lime at 420 feet; shallow.
12, NE	W. O. Pinnell	522	Gas well?
17, NW. NW	Vandyke	535	Gas sand 323–343 feet; sand and oil 472–498 feet; lime 501 feet. Pumped 6 barrels heavy oil in two days.
20, SE. SW	T. M. White	?	Dry; shallow.
20, SE. SE	J. A. Moore	602	Dry.

T. 12 N., R. 13 W.

Section	Farm	Total depth *Feet*	Remarks
7, NE	Ezra May		Gas; no record; shallow.
17, NW	Daniel Shover		Gas well (?); shallow.
18, NW. NE	Cort Pinnell	522	3 holes. Best record, sand 352–378 feet; sand 414–440 feet; sand 490–518 feet. Good shows of oil; lowest sand best.
21, NE. NE	Clapp	400	Dry.
32, SW. SW	?	?	Dry; shallow.
33, SW. NW	Gassaway	?	Dry; shallow.

On the following approximate locations, some of which are doubtful, holes are reported as drilled and some gave gas. All holes were shallow, probably none over 600 feet.

Sec. 3, SE., Noel Marksworth; sec. 4, NW., Jos. Zink; sec. 8, NE., Sailee; sec. 9, NW., W. D. Bartness; sec. 9, SW., V. Perisho; sec. 16, SW., E. M. Perisho; sec. 17, NE., W. McEvoy; sec. 18, SW., W. H. Saston.

T. 11 N., R. 10 E.

Section	Farm	Total depth *Feet*	Remarks
3, NE	V. V. Rennels	1100	Sand 660–740 feet; sand 880–1100 feet; salt water at bottom.
5, NE. SE	Rennels	400?	Dry.
10, SE. SE	?	905	Dry.
11, cen	Sargent	590	Dry.
12, SW. SW	Fuqua	535	Dry.
13, NW. SE	C. Fuqua	?	Dry; shallow.
15, SW. NE	Gossett	650?	Dry.
16, NW	W. Rhoads	860	Dry.
	W. Rhoads	816	Dry; show.
20, SW	A. Stull	742	Dry.
22, NE	W. R. Cox	756	Gas and show at 600 feet.
24, SE. SE	Berkley	?	Dry; shallow.
24, SW. SW	J. Law	?	Dry; shallow.
25, NE. SW	D. Monks	?	Dry; shallow.
26, NW. NE	Gosset	664	Dry.
27, NE. SE	Highbell	800	Dry.
35, SW	V. Richardson		No record; shallow.

T. 11 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
1, SW. NW	M. A. Tarble	587	Dry.
23, NE. NW	E. Block	529	Dry.
36, SE. NW	R. Rogers	?	Dry; shallow.

T. 11 N., R. 13 W.

Section	Farm	Total depth *Feet*	Remarks
8, SE. NE	A. C. Hammond	512	Dry.
17, NW. SW	D. Hazen	760	Dry.
19, SE. NW	Welch	?	Dry; shallow.
22, SW. SW	Gorber	609	Dry.
30, NE. SE	Sharp	606	Gas at 335 feet.
30, NE. SE	Sharp	?	Dry; shallow.

T. 10 N., R. 10 E.

Section	Farm	Total depth *Feet*	Remarks
3, NW. SW	Brandenburg	516	Dry.
4, SE. NW	A. Edwards	?	Dry; shallow.
9, SE. SE	Union Centre	?	Dry; shallow.
9, NE. SE	A. Rhue	?	Dry; shallow.

15, SW. NE	W. Herr	900	Dry.
16, SW. SE	E. Robey	700	Dry.
23, NE. SW	Culp		Dry; shallow.
26, NE. NW	McKeen	707	Dry.
26, NW. SE	McKeen	675	Dry.
35, NE. NW	Z. Low	600	Dry; 2 holes.
35, NE. NE	Woodburn	600	Dry.
35, NW. SW	Yanaway	800	Dry.
36, NW. NE	V. Bell	710	Dry.

T. 10 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
16, NE. NW	Perkins	1015	Dry.
16, SE. NW	Perkins	1124	Dry.
16, SW. NW	Shiver	600	Dry.

T. 10 N., R. 13 W.

Section	Farm	Total depth *Feet*	Remarks
6, SE. SE	Cox	?	Dry; shallow.
7, SE. SE	Wells	480	Dry.
7, SE. SE	Wells	585	Dry.
8, NW. NE	Rowe	?	Dry; shallow.
8, NE. SW	Rowe	650	Dry.
8, SW. NW	Martinsville	653	Dry.
13, NE. NW	Noyes	650	Dry.
15, SE. SE	Whitcomb	715	Dry.
17, SE. NW	Newman	645	Dry.
17, SW. NW	Newman	715	Pumped 5 barrels.
18, NE. NW	McNary	550	Dry.
21, NE. SW	Moore	1010	Dry.
21, NW. SW	Moore	700	Dry.
25, SW. NW	Hill	1001	Dry.

T. 9 N., Rs. 10 and 11 E.

Section	Farm	Total depth *Feet*	Remarks
3, SE. NW	Watson	806	Dry.
4, SE. SE	Stark	1075	Dry.
4, NE. NW	Fancher?	?	Show; shallow.
10, SW. NW	Patrick	?	Dry; shallow.
14, NW. SW	Fitch	1085	Dry.
14, NW. SE	Thomas	?	Dry; shallow.
19, SW. SE	Sanford	1000	Dry.
23, SE. SW	?	1002	Dry.
24, SW. NE	Reeds	1163	Dry.
25, NE. SE	Sample	?	Dry.
33, SE. SW	Rush	664	Dry.
34, SW. NE	Gardner	?	Shallow.

T. 9 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
17. SW. SW	Bell No. 2	760	Dry.
17, SE. SW	Klein	1024	Dry.
18, NW. NE	Witmer	1120	Dry.
19, NW. NE	Bell	1026	Dry.
20, NW. SE	Baughman	530	Dry.
29, SW. NE	Slusser	892	Dry.
31, SW. NW	Flint	674	Dry.
32, SW. SW	Foster	692	Dry.

T. 9 N., R. 13 W.

Section	Farm	Total depth *Feet*	Remarks
11, NE. SE	Drummond	1042	Dry.
17, SW. SW	Bennett	1635	Dry.
17, SE. NW	Reed	?	Dry; shallow.
17, NE. NW	Doran	?	Dry; shallow.
17, NE. NE	Reed	?	Dry; shallow.
20, NE. SE	McDaniel	720	Dry.
21, NW. NW	?	?	Dry; shallow.
27, NE. NE	McDaniel	900	Dry.
29, SE. SW	?	975	Dry.
31, SW. SW	Johnston	600	Dry.
33, NE. SW	?	1001	Dry.
36, SW. SE	Canädy	1300	Dry.

T. 8 N., R. 10 E.

Section	Farm	Total depth *Feet*	Remarks
5 Centre	?	1275	Dry.

T. 9 N., R. 14 W.

Section	Farm	Total depth *Feet*	Remarks
5	Sample	605	Dry.

FUTURE PROSPECTING

Introduction

SOME CHARACTERISTICS OF THE PRODUCING FIELD

In the consideration of future prospecting in this area, the conditions which have a direct relation to the future possibilities are very complex. The detailed study of the producing pools shows many conditions which do not permit of explanation by any theories of oil accumulation that have been previously advanced.

The reservoir rocks or "sands" are sand, shaly sand, limestones that have been dolomitized and rendered impure and porous by weathering, and in cases jointed and unweathered limestone. The porosity of these sands is found to be reduced either gradually or abruptly by the occurrence of shale and other slightly porous rocks in their stead; by the reduction in, or the absence of, porosity due to weathering, or by the non-deposition of those parts of the section that should contain the reservoir rock. This loss of porosity is sometimes referred to as "dead-ended" in lieu of a more suitable word that would equivalently facilitate discussion.

The great majority of these producing sands are believed to exist and produce over relatively small areas. The true sands are enclosed in shale or other slightly porous rocks and the weathered limestones are capped by unweathered limestones or shales and laterally pass into dense unweathered rocks.

The character and distribution of certain sands seem to be due to earth movements from time to time which resulted in uplift, erosion, and depression so that subsequent sediments progressively overlapped erosional surfaces. Thus most of the producing Pennsylvanian sands owe their existence as sands to the local relief of the pre-Pennsylvanian surface and to the proximity of a point of land along the oil-producing uplift which extended far out into the Pennsylvanian seas. With the northward advance of those seas an increased overlapping thickness of Pennsylvanian beds was deposited. In addition to causing deposition of spits the point of land diverted sediment bearing waters to areas of shallow water and island conditions beyond the point.

In different parts of the rock section erosion and weathering permitted dolomitization and silicification of the limestone, and enlarged the joints of different beds. The alteration of residual rock at and near these unconformable surfaces is found to vary with the type of original rock, the oolitic and coralliferous beds being more markedly weathered and porous than the fine-grained or shaly beds. An unconformable limestone top showing secondary effects of weathering is sometimes referred to as the "crust." Truncation of different limestone formations allowed selective weathering, and the extent to which the formations were truncated controlled locally the depth in the formation at which weathered beds are found. The term truncation effect is applied in that sense as contrasted with "crust," which refers to the immediate altered top part of a limestone.

The report mentions "erosional highs" meaning eroded rocks which remain relatively above the surrounding formations, and "structural highs" as uplifted domes, anticlines or monclines on the uplift. Beneath the younger formations in many areas, the erosional highs correspond in position with structural highs.

Some sands that do not exist in outcrop but which extend over large areas and contain salt water have failed to provide oil production on the many structures that are productive in other sands both above and below them. Sands known to provide oil where they show a very noticeable decrease in porosity, produce only salt water on structures where the sand is found with its usual marked porosity.

The pressures of oil, gas, and water encountered in the known isolated sands cannot be readily explained by hydrostatic head.

The thicknesses of individual pays recorded in logs cannot be considered accurate, for such pays are rarely uniform in porosity and productivity. The amount of oil per foot of pay or sand apparently increases with the number of individual pays or sands that constitute the total thickness.

Some sands of all producing types are known to be in direct contact with shales of considerable thickness in the locality within which they produce oil. Some of the organic matter in such shales is believed to be convertible to an oil resembling petroleum by the application of heat. The amounts of oil that are or were possible to be obtained from the shales are considerably greater in any locality than the indicated total oil that exists in the sands.

Part of the writer's conclusions as to the theory of oil formation and accumulation in Illinois is not in a form to justify publication at this time. Consequently the discussion of future prospecting treats the possibility of production from some sands without a definite expression of opinion.

IMPORTANCE OF STRUCTURE

The fundamental consideration is the location of anticlinal structure. Other considerations are: the location of domes or flattenings on any anticline; the relation of Pennsylvanian bedding to Mississippian bedding and to the eroded top of the Mississippian; the presence or absence of different parts of the rock section at the place of doming or flattening; the nature of the sands as determined by the effects of old sea currents and shore lines; the type of sediment either altered or unaltered in the different parts of the rock section; the existence of sands productive elsewhere and their relation at the place considered to large salt water bodies.

In considering any part of the area described in this report, only partial data can be know ahead of the drill but some knowledge of local and regional conditions, with varying degrees of information concerning structure, will in most cases reduce the risk of failure.

As presented in the classification of productive sands in the larger report, the Pennsylvanian and Chester sands do not require actual doming to permit oil production, and are put in Group I as contrasted with Mississippian and older sands (Group II) which, on the whole, require distinct domes.

The effective use of some of these facts is demonstrated in the development of the new production in the Martinsville area,[5] and the proving of the Oakland dome, which has not yet been described in publication.

In relation to oil production, this report emphasizes the importance of structure in existing beds. But in addition it has been demonstrated that many essential subordinate conditions are directly related as to origin, to some phase of structure. Consequently structural knowledge is even more important.

BELLAIR-CHAMPAIGN UPLIFT

The limits of the Bellair-Champaign uplift are approximately known, both in and north of the area of production, although the data at hand are far from complete. Within this uplift, holes must be drilled and some samples and records obtained to permit further interpretation of the structural behavior. With this approximate knowledge, it is important to discover if possible any regular or irregular occurrence of domes in the uplift.

CROSS FOLDS

Unfortunately the continuous production along parts of the uplift, due to the complex conditions by which the structure permitted the Pennsylvanian and Chester sands to produce, affords little evidence of axes of folding that existed before the Pennsylvanian beds were folded. In parts of the field partial knowledge of the Mississippian structure has been obtained. The writer suggests that closed structures in the uplift are related to a series of so-called cross-folding axes which run a little east of north and west of south. The following tentative axes are shown by numbers on Plate I:

Axes of cross folding

1. Parker pool to Siggins pool.
2. Martinsville pool to South Johnson pool.
3. North Casey pool to York pool
4. Oakland dome.
5. Middle Casey Township pool.

6, 7 } Licking Township.

8. Warrenton to Borton.

They are listed in the order of probability of existence judging from present data. The Parker-Siggins axis, designated as No. 1 on Plate I, is the most definite, and is based on Pennsylvanian structure in the Parker and Siggins pools, the axis of structure in the Mississippian in Parker Township, and the apparent presence of a similar Mississippian closure in the Siggins pool.

[5] Mylius, L. A., Ill. State Geol. Survey Press Bulletins, Oct. 1919, July 1920.

The Martinsville and South Johnson domes, and the Bellair pool, offer somewhat less amount of data on the Mississippian but the resulting axis shown as No. 2 on Plate I, is parallel to axis No. 1, and seems to strengthen the existence of both.

The North Casey to York Axis No. 3 parallels axes Nos. 1 and 2 and is submitted partly for that reason. The Oakland axis No. 4 seems to have a similar trend. Axes Nos. 5, 6, 7 and 8 have less structural data to justify recognition, but as they parallel axes Nos. 1 to 4 their existence is considered probable.

If, as suggested, that there is a series of cross folds with a systematic trend this is a vital point in prospecting. Such axes will cross the high part of local structures, but may not parallel their longer axes, especially in the bedding older than Pennsylvanian. The eight axes are not all considered major folds and are not all that would be expected; there may be other major and minor axes paralleling them.

Crawford County

In Crawford County, as emphasized by Plates I and II, there has been very slight commercial development of pay horizons in the Chester and in the upper part of the Lower Mississippian. Isolated spots, which are noted on Plate I, obtain production from undoubted Chester sands, and in a few localities not noted, production may be coming from sands near the top of the Chester. Not more than four or five holes in this whole county have gone through the Chester where the shallower Pennsylvanian has been productive, without obtaining production from the Chester. As described in the complete report, and in Bulletin 22,[6] the association of Chester production with Pennsylvanian production is marked. The existence of a system of cross folds is probable, but has not been studied in this county. The Chester production, as noted, will be affected by discontinuity of individual pays and consequently will not need complete structure closures (page 31). The structure, though not at great variance in the area of production, will not be parallel with the Pennsylvanian structure. In the western part, especially, of the producing area in Crawford County there should be considerable testing to and through the Lower Mississippian crust. Such testing would prospect all Chester sands and the McClosky. Testing would be best where the shallow sands produce, but undoubtedly pay from the deeper sands will occur in places where the shallow sands are not productive. Since the Chester produces in places in Crawford County

[6] Blatchley, R. S., Oil fields of Crawford and Lawrence counties: Ill. State Geol. Survey Bull. 22, 1913.

and also north and south of the larger Pennsylvanian producing area of Crawford County, there is undoubtedly a large reserve of Chester oil in this region. In addition there is a possibility of western flank production as described for the Clark County area (page 49).

The Present Producing Area North of Crawford County

POSSIBILITIES OF PRODUCTION IN RELATION TO CROSS FOLDS

The influences of tentative axes of cross folding may be considered first and separately so they will not be confused with the various known and suggested sand conditions detailed later.

In Tps. 8 N. and 9 N. northward on axes Nos. 6 and 7 (Pl. I), favorable structural conditions probably exist, but there is no information to show where closures may be located.

Northward a relatively short distance on axis No. 2 in T. 10 N., a productive structure is possible, but southward the axis would seem thoroughly prospected except between the south Johnson and the Jasper County pools. The general synclinal condition northeast and southwest should be noted.

Northward on axis No. 5 it is possible but not probable that productive structures exist. However, southward in Tps. 8 N. and 9 N. some closing of structure is probable, perhaps near the southwest corner of T. 9 N., R. 14 W.

Axis No. 3 has been partially tested northward without favorable results, but there may nevertheless be a productive structure. There have been shows of oil in northeast Parker Township, but farther north general synclinal conditions exist. Southward new producing structures are possible, but not probable, partly on account of the western synclinal basin.

On axis No. 1 the gas and shows of oil north from the Parker pool suggest that this area may still yield production. Southward beyond the Siggins pool, production is possible but not probable.

CLASSIFICATION OF AREA BASED ON AVAILABLE DATA

In this area, considering future prospecting in the Pennsylvanian[7] and Chester, the highly probable existence of some sands closely related to present production and also to structure, will in cases warrant prospecting where local conditions are not definitely known.

Future prospecting, aside from the deepening of wells in present producing rock zones, may be classed in relation to the certainty of favorable structure of the Mississippian and lower horizons beneath this shallow-producing area. This necessitates arbitrary divisions based on existence or

[7] As described in the complete report, the discontinuous, oil-producing Pennsylvanian sands will be represented by few if any corresponding sands off the uplift.

lack of data rather than on conditions as they may finally be revealed.

First class: The first class includes areas where domes in Mississippian and lower strata are considered definitely demonstrated.

a. Where the Missssissippian dome has been definitely outlined—example, Parker Township dome, T. 11 N., R. 14 W.

b. Where a dome is demonstrated and has on it producing Pennsylvanian sands, but where the exact direction and relief of the axis in pre-Pennsylvanian formations is not yet known. This is typified by the Siggins pool, T. 10 N., R. 10 E.

c. Where a dome is considered certain but the shallow production does not occur over the whole dome, and sufficient data are not available to show the exact direction of axis and the extent and relief of structure in the older formations. This is typified by the Martinsville dome, T. 10 N., R. 13 W.

Second class: The second class includes localities having marked domes in the Pennsylvanian which suggest domes in the Mississippian, although the exact relation with the underlying Mississippian bedding has not been established. Such a dome occurs in secs. 26, 27, 34, 35, Johnson Township.

Third class: The third class includes areas in which the Pennsylvanian shows some doming, and some information on the Mississippian indicates at least slight doming, and the chance for sufficient structure is considered to be worth testing. This is represented by the Bellair pool.

Fourth class: The fourth class includes localities in which the Pennsylvanian shows domes but the regional behavior of the underlying Mississippian introduces some question as to their existence in the Mississippian. This is illustrated by the dome in Casey Township, sec. 14, T. 10 N., R. 14 W., the Vevey Park dome, T. 10 N., R. 10 E., and the York pool, T. 9 N., Rs. 10 and 11 E.

Fifth class: This class is represented by localities with only slight Pennsylvanian doming, warping, and flattening, in general paralleling the anticlinal zone. This includes the North Casey pool, the main Casey pool, and the north half of Johnson Township, Tps. 9 and 10 N., R. 14 W. Whether the Mississippian has sufficient structure to affect favorably any of the horizons, and just where such favorably affected parts exist, can not be stated at this time.

Sixth class: This class includes areas paralleling known Pennsylvanian flattening, and also the general anticlinal trend, in which the upper sands are missing or have failed to produce. This may result in a strip of territory with commercial oil in lower sands terminating against the high pre-Pennsylvanian surface. An example of this class is found in the

area paralleling and in general lying immediately west of the Pennsylvanian production in Casey and Johnson townships.

Seventh class: The last class comprises areas on the general trend of the fold between producing localities or those in which the axes of cross folding suggest possible closures, where shallow producing sands are known to be missing or poorly developed, and where production might be obtained from deeper Pennsylvanian and Chester sands not yet thoroughly tested.

In considering all classes except the first, later reference should be made to the elevations on the base of the Mississippian shown on a map accompanying the main report. The amount of data available does not seem to justify the construction of a contour map, but additional drilling in this territory supplementing the present facts will permit the detection of any doming or local flattening of the Mississippian.

FIRST CLASS

Parker Township dome (Tps. 11 and 12 N., Rs. 11 E. and 14 W.).—On this dome considerable production is obtained from shallow Pennsylvanian sands which pinch out or are restricted over the dome, and this production was traced off structure and outlined (Pl. I) so that it is not likely that any additional Pennsylvanian production exists.

The upper 200 feet, approximately, of Lower Mississippian (depth to the top 300 feet) has some additional production available as shown by the tables for that pool in the main report. Its distribution will conform to the bedding and not to the erosional surface as did the pay in the upper 100 feet.

The horizon of the main Mississippian salt water (depth 500–600 feet), does not show any restriction of porosity. This horizon locally does not have truncated beds in contact with petroliferous shales. It has been saturated with salt water on all locations tested to date and it extends over a large area.

The basal Mississippian[8] (Carper sand of Martinsville) the depth to the top of which here is about 1,000 feet has given shows of oil, and in places some oil can undoubtedly be pumped from it.

The dolomitized Devonian crust (depth about 1200 feet) has given shows of oil, but near the top of the dome the thickness of this zone, free from salt water, is only about 10 feet.

The "Niagara"[9] water sand (depth approximately 1300–1400 feet)

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[8] The first well of the Trenton Rock Oil Company, Carper No. 1, gave 150 barrels after shot, dropped to about 25 barrels in about a week but was producing about 20 barrels a day at the end of six months. The average initial production of the first 10 wells was about 70 barrels settling to from 10 to 35 barrels approximately. The production appears to "stand up" exceptionally well.

[9] Drillers' nomenclature—it is often in the basal Devonian; this is discussed fully in the complete report.

gives no indication of restricted porosity, and in this locality there is no shale in contact with it. This sand has always been found saturated with salt water and extends over several counties.

The limestone in the Maquoketa, termed "Clinton" by the drillers, (depth to the top, about 2125 feet) and the Trenton (depth to the top, about 2265 feet) undoubtedly will carry quantities of oil over this dome, the amounts at each location having a direct bearing on the contours of the dome and any variation in porosity.[10] At this time these deep wells do not cause active prospecting as the daily production for the depth is relatively small. The future, however, will warrant complete development of these lower pays and in this connection the contours on the Trenton in the complete report, will be useful in directing drilling. Some hole on the dome, in the area of productive Trenton, should be drilled to the St. Peter sandstone. If this horizon or the Stones River just above will produce anywhere in this area it should produce on this dome.

The Parker dome apparently has a large oil reserve, most of which may wait until the value of oil will warrant more active development. Details of this pool are given in the complete report.

Siggins pool (T. 10 N., Rs. 10 and 11 E.).—Over part of the Siggins pool the Pennsylvanian still offers additional possibilities due to deepening. The tables of well data and contours on the lowest Pennsylvanian sand in the main report, will be of assistance in such testing. In addition, on the western flank of this structure there is a possibility that a sand lower in the rock section of the Pennsylvanian and not represented on the productive dome may be terminated against the pre-Pennsylvanian surface and cause production on the immediate flank of the present producing area. In addition, the Chester, which may be about 50 feet thick at the top of the dome, will have increasing thickness and also have sands coming in to the west that are not represented over most of the present producing area. Such sands also present the possibility of an irregular strip of productive areas on or close to the west flank of present production.

Considering the Lower Mississippian, the formation (depth about 650 feet) that was subjected to truncation was the St. Louis, a fine grained limestone, and this resulted in a slightly porous weathered cap. Large amounts of oil should not be expected in the immediate top, although this production may contribute with that of other horizons to make commercial wells. Underlying the St. Louis is the Spergen (depth 875–1075 feet) which is the main productive horizon of the Parker pool. It has not had

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[10] In Parker Township, Trenton drilling has been on edge leases before abandonment. An average well in the part worth drilling at present starts at about 100 barrels after shot and drops to 10 in about three months, but from that time on drops little more than one barrel per year.

the chance for surface waters to develop as much porous dolomite as at the Parker pool, but some locations should find pays.

The condition of the main Mississippian water sand (depth about 1100–1200 feet) will be the same as in the Parker pool. Some petroliferous shale may occur below it and above the Carper sand.

The basal Mississippian (Carper sand), the depth to the top of which is about 1575 feet, has given shows of oil from two holes of the four that went through it, and may in cases, depending on the economic question as to cost, contribute some production.

The surface beds of the Devonian (depth about 1825 feet) show more water-free-section than at Westfield and have given gas, as noted in figure 3, with shows of oil. In this horizon, additional gas wells are probable and some small oil wells are possible. In this connection, figure 3 shows the

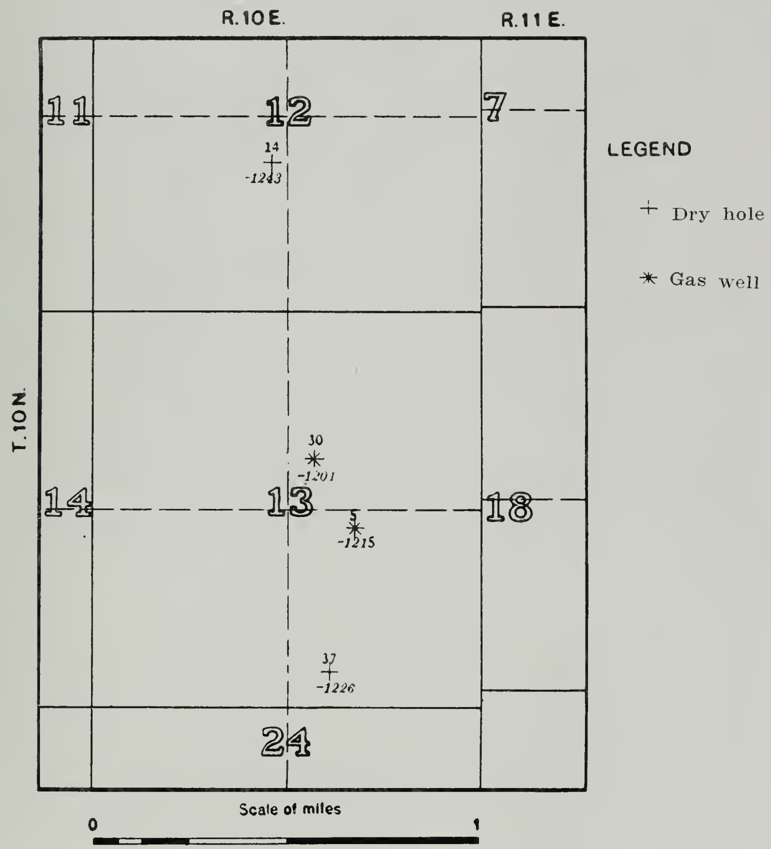

FIG. 3. Elevations of the top of the Devonian referred to sea level in all tests reaching that depth in Union Twp., Cumberland County.

location of the four holes which penetrate the Devonian and gives elevations on its top. It will be seen that some area of sand as favorably located as the good gas well, hole No. 30 in NE. ¼ sec. 13, T. 11 N., R. 10 E., has been untested to this depth. Although a great part of the gas has undobtedly been drawn by this original well, which is old, enough gas may be obtained to make the drilling of gas wells profitable, especially as on some leases the supply of gas for power is small.

The water sand of the Niagara (depth about 2000–2100 feet) has not been penetrated but similar conditions to those on the Parker dome should be expected.

Oil will probably be found in the Maquoketa limestone (depth to top, about 2850 feet) and in the Trenton (depth to top, about 3000 feet), and again as in the case of the Parker pool it is a question of the amount of recovery as compared with the cost of drilling these wells. Large wells are possible but not probable. Long-lived wells can be expected.

The Martinsville dome (T. 10 N., R. 13 W.).—On this dome the shallow production in the upper 500 feet does not directly reflect conditions that will govern production below. In this vicinity the chance for additional Pennsylvanian light production is good, and the chance for some wells in the weathered top part of the Mississippian, which is St. Louis, (depth to the top, about 500 feet) is also good. Most of this production must depend on a higher price for oil.

The Spergen (depth about 650–850 feet) which produces at the Parker pool has not been subjected to equivalent truncation in the Martinsville dome. It is not in contact to any extent with Pennsylvanian or other petroliferous shales, but when more wells have been drilled, this horizon will probably give enough oil locally to warrant pumping. The main Mississippian water sand (depth, about 850–950 feet) has seemingly no restriction and also has no contact with petroliferous rocks.

In the Martinsville pool the future of the Carper sand (depth to the top, about 1350 feet) is important and undoubtedly this horizon would produce oil over an area of from one to two square miles, depending on the price of oil. In most cases the sand at this horizon is probably present in sufficient quantity to give some oil and undoubtedly will be free from water if the location is sufficiently high in relation to structure. The exact outlines of this dome in the Mississippian will have to be demonstrated by the drill. The data and development to date seem to verify an anticlinal axis a little east of north. The resulting producing area will probably be longer north and south than east and west; also southward on the axis there is a possibility of productive isolated spots.

The whole of sec. 30, T. 10 N., R. 13 W., should give production in the Carper sand except along the western edge of the NW. ¼ where the width

of the non-productive strip will have to be shown by the drilling outward from the center of sec. 30, and along the western edge of the SW. ¼ where production will probably be found farther west than in the NW. ¼ and may even reach the western section line. Along the eastern edge of sec. 30 production would be expected to reach the eastern section line in the NE. ¼, but is not expected to extend as far east in the SE. ¼ of the section.

In sec. 19 production should be found in part of the E. ½ SW. ¼, and W. ½ SE. ¼, and possibly in surrounding parts. The locality near the center of the south line of that section would be the best location for tests until drilling progresses outward from sec. 30.

In sec. 31, production will probably be found in the NW. ¼. The best locality to test at present is near the center of the north line of the NW. ¼. Some production is also probable in the NW. ¼ NE. ¼.

In SE. ¼ SE. ¼ sec. 26, and in NE. ¼ NE. ¼ of sec. 36, Casey Township, some production is probable.

The exact limits of production will be controlled by the porosity and thickness of sand, factors of more importance locally than the structural situation.

The size and the suggested life of wells from the Carper sand make it rather attractive. The wells are not large producers so far, nor could that be expected from the type of sand encountered, but they settle to from 10 to 35 barrels per day, which is well above the average in this northern field.

The Devonian top (depth about 1520 feet), underneath the chocolate shale of the Sweetland Creek, has on the sides of this structure about 20 feet of water-free-sand with shows of oil. Some locations may give wells in this horizon higher on the dome in the area now being developed with wells in the Carper sand. The "Niagara" water sand (depth 1650–1750 feet) has been saturated with salt water in the three holes that have penetrated it. The sand is very porous and has no petroliferous shale in contact with it. The Maquoketa limestone (depth to the top, about 2525 feet) and the Trenton (depth to the top, about 2700 feet) have shown oil on the side of this dome and will undoubtedly give wells. The porosity of the Trenton and the show of free oil were in excess of those found at the Parker pool, and it is reasonable to expect some better wells here. However, since the depth here is 300 feet greater and the probable production not large, the development of these two horizons might well be deferred.

It is evident that considerable oil still remains to be developed on the Martinsville dome and southward along the axis of folding where isolated small areas of production may be encountered. However, prospecting

southward in Orange Township is inadvisable until the Carper sand production has been outlined on the Martinsville dome.

SECOND CLASS

South Johnson pool (T. 9 N., R. 14 W.).—The dome in secs. 26, 27, 34, and 35, Johnson Township, does not definitely demonstrate but strongly suggests that the Mississippian bedding domes at this place. It should be tested below the Lower Partlow sand (Pennsylvanian) the top of which is about 600 feet. The dome should be tested both east and west of the present producing area for possibilities in both the Pennsylvanian and Chester sands that may terminate or pinch out over the dome. The maximum depth of a test for the Chester on favorable structure would not be over 800 feet, and a depth of about 1000 feet would be sufficient to test both Pennsylvanian and Chester on either flank. Furthermore in the Lower Mississippian (depth to the top about 800 feet) some Ste. Genevieve which has been subjected to erosion may exist and offer a chance. Regardless of the age, the Lower Mississippian crust (if the Ste. Genevieve is missing), should in places contain small quantities of oil. The underlying St. Louis and Spergen (depth 800–1400 feet) have not had any local truncation that would result in marked porosity, nor have they been in contact to any extent with petroliferous rocks. The horizon of the main Mississipian waters may show lessened porosity. The Carper sand (depth to the top about 1900 feet) offers a good chance. It will show as much thickness of water-free-section as found at Martinsville, and should still have sufficient porosity to allow some accumulation of oil. Much bigger wells than those found in the Martinsville pool should not be expected.

The Devonian (depth to the top about 2100 feet) offers a chance for productive wells. It may have a greater section free from water than it has at Martinsville. The Niagara water sand should show lessened porosity and there may be some shale in that part of the rock section. The Maquoketa (depth to the top about 3250 feet) and the Trenton (depth to the top about 3400 feet) offer a good chance of oil, should the Carper sand testing prove a Mississippian dome. The drilling to this horizon, however, is still deeper than at Martinsville, and as the results from the Maquoketa and Trenton to date do not suggest sufficient porosity to cause considerably larger wells, the testing should not be undertaken at this time.

It will be seen that this locality has possibilities of considerable additional production below the Pennsylvanian, none of which, however, can be treated as a certainty as no definite structure has been shown in the lower beds.

THIRD CLASS

Bellair pool (T. 8 N., R. 14 W.).—The third class is represented by the Bellair pool, which is shown in the complete report, to have marked flattening both in the upper Mississippian and Pennsylvanian, with production in both systems. In the development of the Chester pays the chance of flank Pennsylvanian production has been rather thoroughly prospected, such additional production being possible but not probable. The Chester to date has given some wells on the edges of production in sands that dead-end toward the center of the producing area. The relation between the Pennsylvanian and Chester, and the accentuation in the dip of the Chester as compared with Pennsylvanian is presented in the main report. The two are parallel in parts of the area, but the farther removed from the center of the dome or flattening, the greater the divergence in bedding. The development of more production from Chester pay is probable. However, the erratic extent of individual pays and of the weathered Chester top may make this development more profitable when a dry hole will take less from the total profits than it will at this time. In this pool the obtaining of complete production from the Chester will necessitate the drilling of a greater percentage of dry holes than encountered up to the present time. The contours on the 800- and 900-foot Chester sand zones show many places where they should give wells, but as mentioned, the uncertainty in the lateral extent of the porous producing sand reduces the chance of success in such localities.

The Lower Mississippian (depth to the top about 1000 feet) has probably a little Ste. Genevieve at the top. This has produced a little oil and undoubtedly some locations will find some additional oil in this horizon. The oil production from this sand will from necessity be erratic, and here again the question of chance and the amount of the production expected must direct the prospecting. The St. Louis and Spergen and the Mississippian immediately below the Spergen are only expected to show irregular porosity due to possible rock fractures. They are not in contact with petroliferous shale. The basal Mississippian Carper sand, (depth to the top about 2000 feet), should eventually be prospected on the dome as it should not have salt water encroachment and should have enough sand in associations that would give oil. From the type of sand occurring in that part of the section at Martinsville, the wells in the Bellair pool should not be expected much if any larger than the Carper sand wells at that pool. With such probable conditions the total depth and the price of oil must influence the prospecting.

The Devonian crust (depth to the top about 2300 feet) may have less porosity and more water-free-rock-section than at Martinsville and may

give some oil and gas. The Niagara water sand will probably have less porosity than at Martinsville and may have some petroliferous shales in contact due to change in the type of sediment. It is a possible though not probable producer. The Maquoketa (depth to the top about 3400 feet) and the Trenton (depth to the top about 3550 feet) offer good chances for oil, but with increasing depth, without reasonable hope of much if any bigger wells than are found to the north, the prospecting and development of these sands will depend on economic conditions. In addition to the above points, the flatness of the Upper Mississippian structure introduces a question as to whether this type of structure will accumulate oil and gas in horizons below the Chester. Those sands that have produced here to date are in themselves so constituted as to react to this slight flattening without complete structural closure, in all cases, and on that account prospecting to deeper horizons is more doubtful.

FOURTH CLASS

Central Casey Township pool (T. 10 N., R. 14 W.).—The dome located in sec 14, Casey Township, as will be shown in the complete report offers little chance of developing important pays from deeper strays in the main sand body in the immediate area of production. On the western flank, however, the Pennsylvanian may contain a productive sand which may terminate against the Mississippian along a narrow strip in or immediately west of present production. On the western flank, also, the chance exists for some Chester production, although it is slight, as the Chester remnant is rather thin.

The Lower Mississippian crust (depth to the top about 475 feet), of St. Louis limestone, has given some oil and when penetrated on this dome will undoubtedly contribute small production. The amounts, however, will probably be less than obtained at Martinsville. The Spergen (depth to the top about 650 to 850 feet), due to lessened porosity, is expected to give only erratic production. The condition of the Mississippian water sand will be similar to that at Martinsville. The importance of the Carper sand (depth to the top about 1450 feet) depends on Mississippian structure, for which there is a lack of data at this time. The eastward reversal of the Pennsylvanian and slight data on the Mississippian, suggest reversal of the Mississippian in that direction. Also, cross fold No. 5, suggests a reversal. However, west of Martinsville Township, the eroded Mississippian contains rocks continually higher in the Mississippian section until finally after about 175 feet of additional thickness, some Chester is found. Drilling will therefore have to demonstrate whether or not a reversal in the Mississippian bedding exists underneath this Pennsylvanian dome. The dome should be tested to the Carper sand which, if the structure in the Mississippian proves

favorable, should produce oil. Also, the top of the Devonian would offer some chance of production. The Niagara water horizon is not thought to be much less porous than over the several counties north, nor to have much if any petroliferous shale in that part of the rock section. The Maquoketa lime and Trenton have similar chances in this locality as compared with the Parker and Martinsville pools, but they should perhaps not be drilled unless the drilling through the Carper sand and the Devonian demonstrates a closure or marked flattening in the bedding of the Mississippian and lower formations.

Vevey Park pool (T. 10 N., R. 10 E.).—The Pennsylvanian does not offer as good a chance for production on the west flank in the Vevey Park locality, as in the main Siggins pool to the north. The Chester should be tested within the area of production, although testing for west flank production would not seem advisable until such production is found in the Siggins pool area. Some additional Chester sands may occur to the west, but their occurrence with sufficient structure is doubtful. Also a 1000-foot test should be made southwest from Vevey Park on the chance of finding another structure on cross fold No. 1. Between the main Siggins pool and the York pool the Mississippian structure will have to be determined from future drilling. The testing of the deeper horizons should depend on results in the main pool. There is a possibility of Lower Mississippian lime production in its weathered top (depth to the top about 800 feet) at Vevey Park, but no test deeper would seem advisable at this time. The approximate depths to the tops of the deeper sands are as follows:

	Feet
Carper sand	1800
Devonian crust	2000
Maquoketa lime	3050
Trenton	3200

York pool (T. 9 N., R. 11 E.).—In the York pool, the Chester should be drilled now in the area of production. The Chester is thicker, which increases chances of production. Though the actual structure of the Chester is not known, this general vicinity and the area immediately west should eventually have several holes through the Lower Mississippian crust (depth to the top about 1000 feet). But as noted in the case of Vevey Park, the lower horizons should not be tested until this deeper production has been shown worth while in the Siggins pool. The approximate depths to the tops of these deeper sands are as follows:

	Feet
Carper sand	2050
Devonian crust	2250
Maquoketa lime	3300
Trenton	3500

FIFTH CLASS

Casey and Johnson townships (Tps. 9 and 10 N., R. 14 W.).—The marked doming in Casey and Johnson townships has been noted under the description of other classes. But as shown by the contours drawn on the Pennsylvanian in the main report, there are intermediate producing areas with flat Pennsylvanian structure. Some drilling through the main producing sand is warranted in sections 3, 4, and 5, Casey Township. When the most prominent sand was unproductive some wells found production in slightly lower parts of the rock section. In addition to some inside drilling, small production may be found by testing still lower sands or lower parts of the same sand that are not represented, due to the high Mississippian, in the center of the nose. This nose has no proved Pennsylvanian closure to the north in Parker Township, but it probably exists. The relation between Pennsylvanian and Mississippian structure can not be determined, as the Mississippian has thickened south of the Parker Township pool, and although it is probable, there is nothing to prove that there is a north dip. Thus it would seem inadvisable now to drill here the deeper formations discussed under the Parker dome. The shallower Mississippian crust, St. Louis, depth to the top about 400 feet, and the Spergen of the Lower Mississippian may contribute some oil in the area where Pennsylvanian sands are now producing. This testing would seem advisable, as the drilling of a hole 600 feet deep, or the deepening of some of the present wells in several parts of the producing area, would not be expensive. The Spergen would not be expected to be as porous as at Westfield. It should show some porosity due to neighboring truncation, with some fractures, and should produce if a Mississippian closure or a marked flattening exists. The Lower Mississippian crust can produce independent of closed structure, whereas any Spergen production would be controlled more directly by structure. In the absence of definite proof of Mississippian closure, the chance of production in the limestone crust is better.

South from this north Casey pool, the dome in and around section 14 is discussed under Class IV.

The remainder of the producing area in Casey Township and the northern half of Johnson Township offers changing though similar possibilities. As noted, the rising of the pre-Pennsylvanian surface to the east and the thickening of the Mississippian to the west make it impossible to know the structure below the Pennsylvanian immediately under the area of shallow production. In the absence of definite information the location of such flattenings or closures as may exist can be found only by testing. This testing as deep as the Carper sand may not be warranted at this time, but eventually it will show the approximate Mississippian struc-

ture, and should precede testing to horizons below the Mississippian. In this strip of production in the shallow Pennsylvanian horizons the conditions for production from the different lower horizons which are reached at intermediate depths are the same as those discussed for the Martinsville and for the south Johnson pools in Class I.

The deepening of the shallow Pennsylvanian wells will no doubt be of some benefit and the deepening into the thickened Chester may in places give production. To test chances for production in the Lower Mississippian crust and the Spergen, the holes should go about 300 feet into the Lower Mississippian. This may be the commercial limit of tests unless they indicate Mississippian closures.

In section 24, Casey Township, and south along the eastern side of Casey and Johnson townships, including only the north half of Johnson Township, there is undoubtedly some chance for light production from Pennsylvanian sands. This type of production is demonstrated and rather thoroughly tested in Johnson Township, where small wells occur in small producing areas due undoubtedly to the behavior in the sand and the general flatness of the bedding. In section 24, Casey Township, and that general vicinity, however, there is also considerable promise of light wells in the Lower Mississippian crust. The redrilling of this area, on the east side of Casey and Johnson townships, through the Lower Mississippian crust may be practicable when oil increases in value. It should be emphasized that where the Chester is found capping the Lower Mississippian, the Lower Mississippian has been subjected to truncation due to pre-La Salle folding. On that account one would expect the porosity and the effects of local relief on this porous crust to decrease gradually if not abruptly after the appearance of Chester. Tests noted above going several hundred feet into the Mississippian lime will need favorable Mississippian structure to give production. The crust even when covered with Chester beds will be in contact with petroliferous shales, but its chance of reduced porosity must be considered, and unless the oolitic Ste. Genevieve occurs it is not thought to be promising. Should pay other than crust production be found where the Chester caps the Lower Mississippian it should be related to structure and will be a guide for the testing of deeper horizons. In this locality tests to and including the Spergen will vary in total depth from about 850 to 1200 feet.

SIXTH CLASS

Casey and Johnson townships (Tps. 9 and 10 N., R. 14 W.).—On account of the marked non-deposition of some Pennsylvanian beds toward the high pre-Pennsylvanian ridge to the east, tests should be drilled on the

western edge of the producing area for possible Pennsylvanian sands which do not extend completely over the ridge, and also to test for Chester sands which do not extend over this ridge but which may exist close enough to the flattened structure to give production. These conditions may result in production along a narrow strip on the western edge of the present producing area. This type of production is illustrated partially at least by the production on the Heim farm, section 3, Johnson Township. Such teses, about 850 feet in total depth, would not be costly and would demonstrate the advisability of further prospecting.

SEVENTH CLASS

In the area surrounding the producing pools but where definite information on local structures is not available, there are possibilities of structure on the cross-folding axes Nos. 6, 7, 2, 5, 3, and 1, as noted, page 34, and these areas have more favorable rock section than some of the localities where structure is known. The Pennsylvanian thickens and the sand development is shown to be lower in the rock section and unless the tests went 1000 feet in some cases they would not completely disprove the Pennsylvanian. In addition, some thickness of Chester is usually present. The depth necessary to test adequately any of these areas would not be in excess of 1400 feet, and should production occur, the size of wells would probably be greater than the average of this northern field. The list of logs, with depths (Table 5) is submitted to enable a study of each locality. This list is somewhat incomplete but gives all such tests on which information is available. It is considered advisable to test some of these localities at this time even in the absence of any definite structural knowledge. The testing of the deeper horizons will be warranted only after the Pennsylvanian or Chester has shown production or favorable structure.

Area North of the Producing Field as Shown by Plate I

INTRODUCTION

THE BELLAIR-CHAMPAIGN UPLIFT

The location of anticlinal belts in which closures occur is shown on Plate I and undoubtedly other closures exist. In the territory north of and around Tuscola, the territory just east of and around Ashmore, and near Allerton there are indications of domes which are supplemented by suggested cross folds. Also no local information is available on the area between Tuscola and the Siggins pool, but axes of cross folding suggest structural possibilities. Any classification of this area must be modified by the varied sand conditions. Localities with favorable sands may warrant drilling on less structural knowledge than others with less favorable sand conditions.

The two anticlinal belts representing the approximate eastern and western limits of the Bellair-Champaign uplift (Pl. I), differ somewhat in the

amount of relief above the adjoining basins. The Oakland belt noted chiefly in R. 14 W. has a steep east dip into the Marshall-Sidell syncline as shown by Plates III, IV, V and VII. The west dip of the La Salle belt results in a somewhat greater relief of this belt above the main Illinois coal basin. The west dip of the LaSalle belt is apparently steeper on the whole.

Minor synclines cross these anticlinal belts, but both east and west of the uplift, the formations show regional synclines. Also between the two belts, synclincal conditions exist, but the nature of this central syncline is controlled by the local domes and cross folds. The anticlinal belts as shown on Plate I are not intended to limit the area in which domes may exist, but represent the most probable areas for favorable structure. Any domes found in these areas may extend somewhat beyond the limits shown and independent domes may occur along the cross folds in the central basin between the two zones, but there is no evidence that suggests this probability.

Northward more detail is known on the Oakland belt than on the La Salle. The vital questions are, first, the location of local structures, and second, the occurrence and nature of sands. In T. 15 N., R. 14 W., the approximate contours on the dome shown on Plate VII can be applied to all the lower formations to the Trenton.

Known closures.—The knowledge of known closures north of the present producing pools is very limited. As a result of press bulletins October, 1919 and July, 1920, sufficient work was done by diamond and churn drilling, to demonstrate a definite closure between the towns of Oakland and Newman, (see Pl. VII), though not to indicate its exact area, and also to prove the widening of the zone of uplift. The Oakland-Newman dome is the most definite structure north of production.

Cross folds.—Northward on cross fold No. 1 in Edgar County a closure is possible; the area just south of Kansas may be favorable. Northeast of the known Oakland dome, on axis 4, it is not probable that productive structures exist. However, north of the town of Hutton there may be closures. If a Mississippian structural high is proved near the town of Allerton, it might indicate a possible closure southward, in T. 12 or 13 N., R. 10 E.

OAKLAND-NEWMAN DOME

The dome between Oakland and Newman, as shown by Plate VII, was discovered by testing structure in this anticlinal belt with the diamond-drill. Although the work was not completed, shallow churn drilling has since added sufficient data to make the occurrence of a dome a certainty. The Pennsylvanian is very thin at shown by detailed logs and Table 1, sub-area J. Although light Pennsylvanian production is found on this dome and

around Borton and Warrenton on cross fold No. 8, T. 14 N., R. 14 W., the experience with these extremely shallow and irregularly distributed sands indicates that wells and the individual pools will be small and thorough development may not be warranted until oil has a considerably higher value. Larger Pennsylvanian production may be found on this dome if the steep eastern dip allowed sands of the thicker Pennsylvanian section to be deposited close to the closure, but as the exact place where the steep eastern dip begins is not known, it may not be advisable to prospect for this type of production for the present. No Chester is present on or near the dome and the chance in the Lower Mississippian is slight. Some Spergen limestone capping the remnant of Lower Mississippian may be found basinward to the east of this closure, but within the area of influence of this dome most of the Mississippian beds remaining are entirely of sandy shale, (Pl. II). With the exception of the Kinderhook, the sandy shale is not well sorted or porous. The upper Kinderhook shows sorting, and has a porous sand, equivalent of the Carper, that has given no shows of oil but a hole full of salt water in all holes, even detailed log No. 55, (Pl. I). The porous sand at this part of the rock section is known to extend over a large area. There is some, but markedly less, shale in this part of the rock section than in Clark County. The Devonian in this neighborhood shows ten to fifteen feet of very porous dolomitized crust which has given shows of oil. The sand was oil coated near the dome, but was always flooded with salt water. Detailed log No. 68A shows the best indication of oil and detailed log No. 55, of a well considerably higher on the dome, shows practically no oil but a hole full of water, 1½ feet in the sand. Locally the crust may produce, but there is now no way to ascertain the exact location. The Onondaga (Corniferous) which immediately or closely underlies the chocolate shale in this area weathered into more dolomitized and impure limestone than the less coralliferous and finer-grained Hamilton. This resulted in a large area of weathered crust that is extremely porous and generally with less local variation in porosity than where the Onondaga was not exposed. The upper 150 feet of the Devonian-Silurian, presents some chance of porosity, due to truncation effects. There are possibilities in the upper part of this Devonian limestone, although there is nothing to indicate that the sandstone development at the top of the Silurian will produce. Near the top of this dome, the Maquoketa limestone, depth to top about 1675 feet, and the Trenton, depth to top about 1825 feet, undoubtedly will contain oil, but how much, can not be stated. It is possible that the extreme top of the dome as at Westfield will show somewhat smaller wells than elsewhere. Holes Nos. 62, 65E, and 66 penetrated the Trenton. The cuttings from detailed log No. 66 show the Tren-

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ton to be at least as porous as the producing Trenton at Westfield. That hole showed salt-water saturation in the Trenton, and a very light and non-commercial oil show. However, it is at least 150 feet lower than the top of the dome and as noted at Westfield the possible productive range in elevation of the Trenton top is considerably less than this amount. If it is not considered advisable to go three-quarters of a mile to one mile east of the county line and put a shallow hole to the base of the Mississippian before deciding on a location for a deep test, this dome should be tested to the Maquoketa and Trenton in the neighborhood of the highest contour shown, just east of the county line. It should at least give marked shows of oil in the Trenton. Even failing in production in the Trenton or a higher horizon, a dome of this magnitude would deserve a test of the Pennsylvanian to the east. It is the only dome definitely known north from the productive Westfield pool. From the contours on the top of the Devonian shown on Plate VII, the top of the Trenton can be estimated approximately by subtracting 1,075 feet.

AREA IN THE VICINITY OF TUSCOLA AND NORTHWARD

The formations in the vicinity of Tuscola are about 2000 feet higher than equivalent ones in the Siggins pool, but north and northeast of the Tuscola vicinity the dips are relatively slight. This suggests that in this general locality there are probably domes, although their locations will have to be determined by testing. The La Salle anticlinal belt as outlined suggests where testing work of this sort should be concentrated, but parts of domes may extent beyond its limits. From Tuscola northward the sands that can be expected to give production are few; the Pennsylvanian and the Mississippian are not believed to be present close enough to any closures to offer any chance of production except possibly on the steep western flanks. The Devonian-Silurian could give production in places as the truncation has resulted in many porous beds, illustrated by detailed log No. 44, but the retention of marked amounts of oil can be questioned unless this part of the rock section is capped. In places on the top of the anticline there is no cap, so that this chance should not be considered important. The water supply for the city of Tuscola is in part at least obtained from the sandstone of the Devonian-Silurian and only contains about 500 parts mineral per million. It is possible that somewhat lower Silurian beds may in places give oil production. Undoubtedly the upper Devonian and Silurian beds have a gradual loss in porosity away from the outcrop under the drift until all porosity due to alteration disappears and the beds exist in their less porous original state. This loss in porosity takes place southward down the main pitch of the anticline and possibly to the north, east, and west depending on the dip and extent of previous erosion, in relation

to local structures. The Maquoketa limestone and the Trenton offer the only reliable wildcatting sands. The size of the wells should be expected to be at least as big as those south, and as the depth to the Trenton is considerably less, smaller wells than those already demonstrated in the south would be profitable in this area. The depth will vary as shown in Table 1 from a probable minimum of 1100 feet to a possible minimum of 950 feet, depending on the behavior of local structures.

In prospecting this area for structure the use of the diamond drill or a coring device as a control over ordinary churn-drilling may easily establish a practical datum without depending on the recognition of Devonian or Silurian bedding. The Devonian-Silurian will undoubtedly show as an erosional high, as did the Mississippian to the south, and the association of structure will undoubtedly be closely related to the Devonian-Silurian top which is easy to recognize in ordinary churn drilling. Such an occurrence can afterward be tested for bedding by a relatively few holes. In this vicinity the average depth of holes to test for the top of the Devonian-Silurian which, due to local erosion should not vary stratigraphically more than about 100 feet in the top bed found even where no cap is left, would not average over 350 feet.

As previously stated, should closures be found from Tuscola northward, the chance of production on the western flank is worth considering. The steepness of the westerly dip as illustrated at Tuscola in cross-section, Plate III, may have resulted in the occurrence of Pennsylvanian and Chester sands within the beneficial range of the structure, and the effect of such would be to offer as possible producing horizons many sands that are absent over the anticline.

TUSCOLA SOUTHWARD TO SIGGINS POOL

Northern half.—The area from Tuscola to the Siggins pool may be divided into two arbitrary subdivisions, dependent upon sand conditions, of which little is known. The possible closures due to the axes of cross folding is of importance. Water wells in the northern subdivision from Tuscola southward have indicated that the anticlinal pitch is slight for three or four miles at least. The chocolate shale is found over the Devonian at comparatively shallow depths. A structural closure in this general vicinity from the latitude of Tuscola to T. 13 N., would have the advantage over the area north of Tuscola in that the weathered Devonian and Silurian would be capped by shale. Also the basal Mississippian, the Carper sand horizon, has given shows of oil (see detailed logs Nos. 43 and 44). Any Burlington remaining might produce due to increased shale and better sorting of sediments. The above parts of the rock section are locally in contact with petroliferous beds.

Southern half.—The southern half of the area from T. 13 N., to the Siggins pool has an added advantage of sand possibilities. The development of thick sands in the McLeansboro of the Pennsylvanian demonstrated in the Siggins pool has been shown to exist as far north as Charleston, where massive sandstone, which is well above the sands producing in the Siggins pool, outcrops. In other words, it would seem that the Tuscola point of land continued to cause considerable thicknesses of Pennsylvanian sands at least as far north as Charleston; and even with relatively small thicknesses of Pennsylvanian, favorable structure may give production. The fact that the steep pitch, as mentioned, takes place somewhere between Tuscola and the Siggins pool must not be overlooked, nor that the steep western flank of the anticlinal zone will have in places some minor synclinal embayments from the main western syncline. Should closures be partially or entirely located in such an embayment the increased thicknesses of Pennsylvanian and Chester section would provide many favorable sands. Detailed log No. 109, from which the cuttings were examined before the basal Mississippian was recognized in this area, ought to give definite proof as to the existence of an embayment at that point. The description of the samples indicate the non-existence of a cross syncline, but the samples from this well can not be traced. Although there are no actual details on closures, the chance for marked Pennsylvanian and Chester sands in the area noted just north from the Siggins pool in itself warrants some wildcatting, as the depths of adequate tests will not be in excess of about 1000 feet. North of the present producing area, this locality offers the best chance of obtaining production from the equivalent of the Siggins and other shallow sands.

Summary.—In both these arbitrary subareas from Tuscola to the Siggins pool there is a chance of terminated sands on the steep western dip of any closures.

Testing for the Trenton in the southern arbitrary subdivision should not be considered at this time but should await results of demonstrated shallower structure. From Tuscola to the Siggins pool the key horizons for structure prospecting will be varied. In the northern subdivision as noted, many holes will show the Devonian at shallow depths. Southward, depending on the location of the steep pitch, which is not known, the eroded Mississippian top where it is sandy shale, will offer an equivalent though not as exact a datum for preliminary use. Still farther south Mississippian limestone will occur at the top of the Lower Mississippian section and will be more easily recognized than the sandy shale. This area needs some core-drill prospecting, as changes in the rock section, which are so vital in indicating structure and sand chances, may take place very abruptly.

OAKLAND TO WESTFIELD

In the area between the Westfield and the Oakland domes, both of which are on the Oakland anticlinal belt, the flattening, illustrated in part by longitudinal cross-section, Plate II, suggests the possibility of a dome, the exact location of which cannot be determined. In detailed log No. 92 the Mississippian and lower formations are shown higher than just north of production in the Westfield pool. Detailed log No. 92 indicates the elevation of the Trenton top to be 1553 feet below sea level and detailed log No. 107A, 1716 feet below sea level. Detailed log No. 65E shows the Trenton top at 1446 feet below sea level. Just what position hole No. 92 has in respect to this probable closure cannot be said, but the high part would be expected north and perhaps east of the hole. Production might be obtained here from the shallow Pennsylvanian sands, or the Lower Mississippian limestone, which shows some remnant of porous Spergen, in part at least of this locality. The Carper sand does not offer a good chance of production, nor does the Devonian crust although both are possible. Undoubtedly the Trenton and possibly the Maquoketa will produce oil on any closure. As the Trenton is the only reliable sand in this locality, its prospecting should be partially guided by the importance of Trenton production proved or disproved on the Oakland and Westfield domes. This area has a somewhat better chance of production above the Trenton than the Oakland dome, but the lack of definite structural knowledge more than offsets this advantage. Should the Oakland dome give production above the Trenton, that producing sand will have possibilities at this place.

ALLERTON AND VICINITY

Detailed log No. 33, the basin to the east, and the probability of a reversal of dip to the west and the indicated syncline across the strike of the anticlinal belt near Newman, would suggest the existence of a dome or flattened area near Allerton. This area would warrant prospecting for structure, partially dependent on the results from drilling the Oakland dome. A dome here would have chances similar to the Oakland dome, including Pennsylvanian production on the east, and somewhat better chances in the crust and the upper 100 feet of the Devonian-Silurian. The Onondaga (Corniferous) which alters into a very porous crust has possibly been mostly eroded. The crust that is found does not suggest as great nor as widespread porosity. In this Oakland anticlinal belt the top of the Mississippian may be used as a general guide to the high structures. As will be seen however (Pl. IV), although the sandy shale of the Mississippian approximately conforms with the Mississippian bedding, the exact structure will have to be verified by drilling to the base of the chocolate shale. Such testing has the added advantage of showing the nature of the Devonian crust. The capping Sweetland Creek shale which is discussed in

detail in the complete report offers a big potential supply of oil and probably some production will be developed below this horizon. The truncation, before the uplift, on the Devonian-Silurian section is not thought to have caused enough relief locally to result in the formation of porous beds very far down into the Devonian-Silurian.

WARRENTON-BORTON AREA

Cross fold No. 8 suggests the possibility of closures in all formations in the vicinity of Borton and Warrenton, but no data are available in this area. The different parts of the rock section are very similar to those discussed under the Oakland-Newman Dome. This probable cross fold offers a chance of Pennsylvanian production northward from Borton. In that direction the thickening of the Pennsylvanian may have resulted in some sands that have a wider distribution which should be productive if there is favorable structure. The present light wells are discussed on page 10.

SUMMARY

In considering the northern area as a whole, any dome should be thoroughly tested. The nature of production from Lawrence County north as shown partially by cross-section, Plate II and Table 2, shows that, as certain parts of the sections which produce oil are removed, others have permitted oil accumulation. With a changing rock section each dome shows that one or more specific parts of the section had ideal conditions for oil accumulation. Undoubtedly, all these conditions can not be known ahead of the drill, and although the writer has attempted to draw attention to facts bearing on this, information is incomplete and general. Any untested dome may have some especially favored horizon which may not be important on any previously tested dome.

North of the Area Covered by Detailed Report

North of this area the trend of the La Salle anticline is shown in Illinois bulletins[11] and it is thought that some closures occur in the large area of shallow Trenton intervening between this area and the outcrops at La Salle. Also it is thought that the Trenton was exposed to considerable truncation, before the formation of the uplift, which resulted in some secondary dolomites and northward, underlying the Maquoketa, the Trenton is found in decreased thickness. The Kimmswick phase gradually disappears but varying thicknesses of porous dolomite occur as a crust and at some depths in the Trenton. This increased porosity with decreased depth would justify the search for local structures along this northern part of the La Salle zone. Not enough is known of the unaltered Trenton section as to the greater adaptability of certain beds to weathering than others, or of the

[11] Cady, Gilbert H., The structure of the La Salle anticline: Ill. State Geol. Survey Bull. 36, p. 85, 1920.

porosity of some dolomites that occur in th leower part of the section. The Maquoketa shale cap could be a source of oil for this northern Trenton. The shale is found on decreased thicknesses of the Trenton, this decrease being hardly noticeable in the area that is treated in detail in this report, but being marked farther north where the increased southward pitch of the formations caused greater amounts of the Trenton to be eroded.

Summary of Drilling Data of the "Trenton"

The approximate thicknesses of formations penetrated in drilling into the Trenton may be ascertained from Table 6 in conjunction with Table 1. If the detailed logs and descriptions of individual formations of the complete report could be consulted, more accurate estimates could be obtained, but the approximation should be of practical assistance in test drilling.

Core Drilling for Structure

INTRODUCTION

At the recommendation of the Illinois State Geological Survey, diamond drilling was commenced on a part of the Bellair-Champaign uplift, first to locate exactly the axes of the folds, and, second, to locate domes on these axes. Recommendations[12] were made in an area where doming was suggested but not proved. Diamond drilling was begun by the Louillo Oil Company of St. Louis, Missouri, who drilled, however, only one hole, but Mr. Charles H. Lewis of Harpster, Ohio, carried on the work for nine more diamond drill holes. The records of these holes are given in the complete report under detailed logs Nos. 44, 45, 46, 47, 52, 54, 56, 63, 67, and 71. This set of diamond drill holes (2 inch core) partially completed the first step in the program, in that they proved the existence of the folds as predicted, but none of the second-stage drilling was undertaken.

The Sullivan Machinery Company of Chicago did the drilling in 1920, under a contract stipulating an average depth of approximately 1,000 feet per hole, although the contract allowed depths of 1200 feet in some holes, at a total cost of about $3.00 per foot. The only additional expense borne by Mr. Lewis was the supplying of core boxes, the Sullivan Machinery Company furnishing coal, water, etc. As churn-drill prices and operating costs in general were considerably higher in 1920 than at this time, that price of $3.00 per foot would be lower now. Three diamond drills were employed, two of the C-N type and one of the P type.[13]

ADVANTAGES OF THE DIAMOND DRILL

The advantages found in using diamond drill for prospecting for structure were as follows: (1) The resulting core showed every variation

[12] Press bulletins of the Illinois State Geological Survey.

[13] Full descriptions of these drills are given in the catalogs of the Sullivan Machinery Company, Peoples Gas Bldg., Chicago, Ill.

TABLE 6.—*Approximate drilling data of the "Trenton" in the sub-areas shown on Plate I*

Sub-area		Depths to 200 feet into Trenton	Part of sub-area	Thickness of drift[a]	Per cent of total depth	Thickness of sand, shale, etc. (easy drilling)	Per cent of total depth	Thickness of lime-stone, thick shells, etc.[b] (harder drilling)	Per cent of total depth	Minimum number casing strings including drive pipe[c]	Size of drive pipe to allow drilling in with 6-inch hole[d]
						Feet		*Feet*			*Inches*
A	Min.	1540	North part, east edge	50	3.2	555	36.1	935	60.7	2; 3 preferable	8¼
	Max.	3925	Southwest	150?	3.8	2175	55.3	1600	40.9	7; 8 preferable	24
B	Min.	1265	Central	150	11.8	160	12.6	955	75.6	2	8¼
	Max.	1905	Around edges	300	15.7	590	31	1015	53.3	2; 3 preferable	8¼
C	Min.	1475	West edge	100	6.7	440	29.8	935	63.5	2	8¼
	Max.	2465	South central	150?	6.1	1180	47.7	1135	46.2	4	12½
D	Min.	1625	North central	100	6.1	590	36.3	935	57.6	2	8¼
	Max.	2425	South and around edges except north edge	200?	8.2	1095	45	1130	46.8	4	12½
E	Min.	1850	Northeast and northwest	50	2.7	870	47	930	50.3	3; 4 preferable	10
	Max.	3525	South central	300?	8.5	1710	48.5	1515	43	5	18

TABLE 6.—*Approximate drilling data of the "Trenton" in the sub-areas shown on Plate I*—Concluded

Sub-area		Depths to 200 feet into Trenton	Part of sub-area	Thickness of drift[a]	Per cent of total depth	Thickness of sand, shale, etc. (easy drilling)	Per cent of total depth	Thickness of lime-stone, thick shells, etc.[b] (harder drilling)	Per cent of total depth	Minimum number casing strings including drive pipe[c]	Size of drive pipe to allow drilling in with 6-inch hole[d]
						Feet		*Feet*			*Inches*
F	Min.....	1925	Northeast........	50	2.6	975	50.5	900	46.9	3; 4 preferable	10
F	Max.....	3190	South and Southwest	200?	6.5	1625	51.0	1365	42.7	5	18
G	Min.....	2000	Northeast corner.	100	5.0	880	44	1020	51.0	3	10
G	Max.....	5675	Southwest.......	200?	3.5	2600	46.0	2875	50.5	8	With 24-in. it would be necessary to use 5 3/16-inch before reaching "Trenton."
H	Min.....	1675	North end.......	50	3.0	600	35.8	1025	61.2	3	10
H	Max.....	3975	South end.......	200?	5.0	1825	45.8	1950	49.2	6	20
I	Min.....	1790	Northwest corner.	50	2.8	710	39.3	1030	57.9	3	10
I	Max.....	3100	Southeast and south central	200?	6.4	1285	41.5	1615	52.1	5	18
J	Min.....	2025	North central....	50	2.4	920	45.5	1055	52.1	4	12½
J	Max.....	2690	Around edges and south	150	5.6	1255	46.5	1285	47.9	4; 5 preferable	12½

K Min	2225	Northwest corner	50	2.2	1110	49.8	1065	48	4	12½
K Max	4050	South central	200?	4.9	1870	46.1	1980	49	6; 7 preferable	20
L Min	2475	Northwest	50	2.0	1150	46.5	1275	51.5	4	12½
L Max	3710	Southwest	150?	4.0	1590	43.0	1970	53.0	6	20
M Min	2465	North central	50	2.0	935	37.8	1480	60.2	4	12½
M Max	3110	Southeast and west edge	150?	4.7	1130	36.5	1930	58.8	5	15½
N Min	2785	Northwest corner	50	1.8	1135	40.7	1600	57.5	5	15½
N Max	4975	Southeast	200?	4.0	2110	42.5	2665	53.5	7; 8 preferable	24
O Min	3210	North end	50	1.5	1265	39.4	1895	59.1	5	15½
O Max	4700	Part west edge	200?	4.2	2160	46.1	2340	49.7	7	24
P Min	2760	North end	50	1.8	1050	38.1	1660	60.1	4	12½
P Max	4200	South end	150?	3.5	1775	42.2	2275	54.3	5; 6 preferable	15½
Q Min	4100	North	100?	2.4	1675	40.9	2325	56.7	5; 6 preferable	15½

[a] Minimum drift will not necessarily be found at location of minimum rock section and vice versa. This introduces an error and should be modified by any data on thickness of drift found in any particular locality.

[b] The limestone on the whole is not very "hard drilling." All gradations exist, but the percentage of limestone and sands that cut the bit is small.

[c] Extra casing strings for the protection of pays or the elimination of strings by the use of mud laden fluid are not considered in this calculation. Details on the different waters will be included in the complete report.

[d] Size of drive pipe determined from casing chart furnished by the National Supply Company.

in the rock section and gave complete detail and accuracy which would have been missing in ordinary samples from drill cuttings; (2) The holes cost no more than churn-drill holes of that depth, approximately 900 feet; (3) The necessity of procuring casing with expense and delays entailed was eliminated; (4) Smaller amounts of coal and water were used, avoiding costly delays; (5) A diamond drill hole is not considered a dry hole as might a churn drill hole of similar depth. In prospecting, the exact depth of all holes going into the ground should be appreciated for an intelligent treatment of any territory, but the tendency is to consider a dry hole in its dry significance regardless of the depth of that hole. In many cases this handicaps prospecting.

DISADVANTAGES OF THE DIAMOND DRILL

The disadvantage found in using the diamond drill without hoping to produce from the hole were as follows: (1) Below a depth of 500 or 600 feet the speed of drilling was much slower than that obtained at these depths with average churn drill machines. No doubt this can be partially remedied by the erection of a derrick that will permit the breaking of rods into longer lengths. It was found, however, that in an average 24-hour day, about 60 feet were drilled in holes approximately 1,000 feet deep. (2) In diamond drilling, the individual ability of the driller is a more important factor than in churn drilling. Parts of some cores that have been taken very carelessly gave no more usable information than ordinary drill cuttings, and in such cases diamond drilling loses a large part of its vital justification. (3) One disadvantage of a diamond drill is felt when the hole is not large enough to permit the shutting off of waters penetrated and testing of an horizon showing oil. A diamond drill core from a formation drilled through with a hole full of water may not show the actual conditions in that sand that will be encountered in ordinary oil-well practice. Many sands have the grains oil-coated and retain considerable petroleum, but the sand may be flooded with salt water and never produce oil. The core from that sand will apparently show an oil-saturated sand, probably related to "dry-hole-scum" that is legendary in the oil fields. A core (detailed log No. 67) of very porous dolomite, oil-coated for 10 feet and showing some oil was found in churn-drill prospecting within a few feet of the diamond-drill location to have very marked salt-water saturation within 1½ to 2 feet of the top of the oil-soaked core, the remaining 8 feet being saturated with salt water. However, this disadvantage can be eliminated when the diamond drill is adapted to holes big enough to permit testing of any such sand encountered. (4) The drift which has been found to be as thick as

200 feet in this area was a distinct handicap to the diamond drill due to the inability of these types of machines to go through the glacial drift efficiently. No doubt this can be remedied but contrasted with the efficacy of other parts of the diamond drilling operation it stands out as a rather exaggerated handicap.

SUMMARY

As noted by Mr. Frank Edson[14] and others, the diamond drill has been and can be successfully applied in putting down a hole that will produce oil, both when giving a core of the entire rock section and when used to recover only a partial core.

For the type of work undertaken, the advantages of using the diamond drill greatly outweighed the disadvantages, and the adoption of small modifications may remove the main objections of diamond-drill usage. If a sufficiently large hole can be drilled to enable the production of oil when oil is found, its use will be more justified.

The information obtained from cores will be essential when the question of reserves of oil becomes of economic importance because, up to the present time oil pays have often been erroneously considered as units.

The use of coring devices that can be used with oil-drilling equipment will undoubtedly challenge the efficiency of the diamond drill. No such devices were used in this investigation, but it is thought that the adoption of such may eliminate or at least narrow the field of the diamond drill.

The cores obtained by Mr. J. W. Knight of the Sullivan Machinery Company from the ten holes drilled were remarkable. Mr. Knight cored and directly superintended the coring of about 4,000 feet of rock section. The missing parts of the complete section through formations varying greatly in character and hardness, was a matter of only a few inches.

Prospecting for closures in this area was not completed with the diamond drill, but partial following up by churn-drill holes proved the existence of the Oakland dome (see Pl. VII) mentioned in Illinois State Geological Survey press bulletins. The applications of this general method of locating domes is therefore demonstrated. The Oakland dome has not been tested to the deeper horizons, and as yet has not yielded commercial production, but as previously noted, the structural information given by this type of work shows within practical limits the behavior of all formations below the Pennsylvanian to and including the St. Peter sandstone.

FUTURE USE OF CORE DRILLS

The application of the diamond drill or coring device in the future may have two distinct phases; first, the use in the present producing fields,

[14] Edson, Frank A., Diamond drilling for production: Amer. Assoc. Petroleum Geologists, Vol. 6, No. 2, p. 91, 1922.

to ascertain the exact nature of the oil reservoirs from which oil is now being pumped to be applied to future methods of recovery; and, second, to ascertain enough detail as to the location and existence of domes to render future prospecting as sure of success as is to be expected in the average use of structural geology in wildcatting for oil. The value of this method is accentuated in the northern area by the thinning and disappearance of the Chester and Pennsylvanian section where favorable structure exists. Conditions affecting and governing production in both the Pennsylvanian and the Chester permit more continuous production along an anticline than do the oil-bearing horizons below the Chester. Consequently, the wildcatting even on these anticlinal zones as outlined will have little chance of finding commercial shallow oil that would directly lead to the later finding of the deeper pays.

The use of the diamond drill alone to prospect any portion of the uplift is not recommended. The diamond drill should be used in conjunction with the churn drills as the latter permits a study of water conditions, that the diamond drill will permit only with the reduction of its efficiency and an increased cost per foot that may overbalance the value of such usage. The successful application of a coring device with the ordinary drilling machine would be ideal.

USE OF KEY BEDS

The varying rock section will necessitate the recognition of a usable key horizon in prospecting with a core machine. From the Siggins pool to the area around Tuscola, the key horizon will vary markedly but with few exceptions it should be taken below the Pennsylvanian. In the selection of key horizons it should be remembered that in the uplift where formations below the Pennsylvanian have been subjected to truncation and consequently to weathering, the individual beds may show marked differences. Evidence of fossil content will in cases be completely removed and other characteristics similarly obliterated. In such areas, notably near Tuscola, an exact key horizon for bedding will from necessity be below the weathered limestones. However in the uplift the Mississippian and Devonian erosional highs have a marked relation to the structural highs, as noted throughout the report. This fact has a direct effect on controlling progressive testing for structure. In many cases the detection of the top of the Mississippian or Devonian will in itself warrant consideration of closed structure, and locally the use of this type of information in lieu of actual structure will reduce the prospecting costs to a very marked extent.

Bull 44, pt F
Pl I, II

Bull 44, pt C
Pl I, II, III

~~4 plates~~